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1976

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This report is designed to survey in some detail the activities of several Federal agencies involved in radiation protection -- such as controlling medical x-ray exposures, managing nuclear power plant effluents, protecting workers exposed to radiation, and monitoring fallout

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1976

An Annual Report Prepared By

U.S. Environmental Protection Agency

Office of Radiation Programs

Washington, D.C. 20460

August 1977

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

To Readers of Radiation Protection Activities:

Since 1974 EPA has published this report to consolidate information about radiation protection activities, which take place in several dozen Federal agencies and cover a spectrum from nuclear power to medical x rays. We hope the report will be useful to those who want an understanding of the full sweep of Federal activities; as in previous years, it will be made available to Congress, key administrative officials, States and the public.

We have established a generic outline to be used every year, so readers may more easily compare activities from one report to the next. Under each source of radiation exposure, substantive areas (such as wastes under nuclear power) are divided into kinds of action -- guidance, environmental impact statements, education, enforcement, research. Selected activities, which will vary from year to year, are then discussed briefly under each category.

Rather than presenting an exhaustive examination of each item, we have identified the responsible agency so that people who want more detailed information will know where to find it. Among the most useful sources are the annual reports of other agencies; while none of them catalogs the overall Federal effort like this report, they do provide more detailed data on their own activities. Another good source for further information is the expanded publications list for 1976, Appendix B. It should be noted that this document serves as EPA's own annual report as well as being a comprehensive overview of other Federal agencies, so EPA's activities are necessarily presented in more detail than others'.

Most radiation protection activities are day-by-day procedures which receive little public attention. In 1976, however, several related issues became controversial and were widely discussed:

--the implications for public health and safety of nuclear power development, especially as the industry continued to be plagued by various difficulties;

--the question of proliferation of nuclear weapons, addressed by President Ford in his October 28 statement that reprocessing and recycling of plutonium should halt unless the associated risks can be overcome;

--the suitability of mammography as a standard diagnostic procedure for older women with no breast cancer symptoms.

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In addition to the public debate on these issues, there were significant developments in the courts. The Supreme Court ruled that EPA could not regulate radioactive effluents from nuclear power plants licensed by the Nuclear Regulatory Commission. The issue of waste disposal was highlighted in a Court of Appeals ruling that the Nuclear Regulatory Commission must explain and document more fully the consideration given to the possible impacts in its reactor licensing process.

In the Executive Branch, many new standards and guidelines were in the works at EPA, including transuranic elements, x-ray guidance for Federal health facilities, and radioactivity in drinking water. Among many other activities, the Bureau of Radiological Health established rules for gonadal shielding during diagnostic x rays; also, at its initiative, the first civil penalty was collected under the Radiation Control for Health and Safety Act of 1968. The Nuclear Regulatory Commission worked on several Environmental Impact Statements of great importance, including those on wastes and on uranium mills. As the body of the report shows, Federal activities relating to radiation protection included almost every Department in one way or another, and 1976 was a very busy year.

Although we have attempted to be accurate and reasonably complete in preparing this report, no doubt there are errors and omissions. We would appreciate your drawing them to our attention, as well as sending us your comments and requests for assistance or information.

W. D. Rowe, Ph.D.
Deputy Assistant Administrator
for Radiation Programs

INTRODUCTION

Americans get most of their exposure to radiation from naturally-occurring sources like cosmic rays. Although we can affect it by where we choose to live, whether we travel by air, or how we decide to vacation, a certain amount of exposure is inescapable for each individual.

The purpose of radiation protection is to limit:

— the dose to individuals which is added to the relatively unavoidable amount,

— the total population dose, which sums all individual doses, and

— the environmental dose commitment, or the sum of all doses to individuals over the time period that a radioactive material is available for interaction with people.

Setting Federal policy about how much and what kind of protection the public should have from any one particular source of radiation is certainly complex, since risks and benefits are often uncertain. In terms of exposure to individuals, the major source which almost everyone agrees could be cut down safely and substantially is diagnostic x-ray procedures. The possible reduction in individual or even total population exposure by controlling most other sources — the nuclear fuel cycle, consumer products containing naturally-occurring radioactive materials, naval reactors, and so on — is comparatively small because doses are small. However, by the criterion of environmental dose commitment, the nuclear fuel cycle and some mining and fossil fuel sources are important because they can produce radioactive materials which, if discharged, persist in the environment for hundreds of years and longer, exposing large population groups. Likewise, such operations produce waste materials that could result in varying degrees of hazard to different population groups for very long time periods, depending on the amount of control or isolation involved.

In addition to setting policy on controlling such sources, radiation protection involves many specific implementing activities, including less familiar problems like regulating the occupational environment of fire alarm makers and transportation of fertilizer. This report is designed to survey in some detail the activities of several Federal agencies involved in radiation protection — such as controlling medical x-ray exposures, managing nuclear power plant effluents, protecting workers exposed to radiation, and monitoring fallout. In addition, some of the less obvious activities are referred to, to give readers a sense of the scope of Federal involvement. This introduction will focus on how the jurisdictional pie is sliced in Congress, among Federal agencies, and between Federal and State authorities.

• Congressional Activities

Although this Report deals almost exclusively with 1976 activities, it cannot ignore the drastic change Congress made early in 1977 in the way it will deal with nuclear energy legislation. The House Democratic Caucus voted on January 4, 1977 to strip the Joint Committee on Atomic Energy of legislative powers, and subsequently both Houses divided its former jurisdiction among other Committees.

The Joint Committee was virtually unique in its importance in steering nuclear power policy. Chartered in the Atomic Energy Act itself — not merely in the House and Senate rules — the Joint Committee was the only permanent one with continuing authority to report legislation. Rather than weaving through the cumbersome legislative process in the usual way, the Committee would introduce its legislation in identical form in both Houses; on the relatively rare occasions when other Members amended its bills on the floor, the Committee would serve as its own conference committee to resolve differences between the House and Senate versions.

The Joint Committee served a useful purpose in the early days of development of nuclear energy. However, the recognition that nuclear energy is only one part of a balanced energy program, together with changing Congressional structures for energy, made the Committee outmoded. After its legislative powers were formally split up, nuclear power legislation began to be considered in the same way as bills for other energy alternatives: from different standpoints affected by many kinds of interests, instead of by one specially chartered Committee where all the Congressional expertise was centralized. The new lineup in the House is as follows:

— military nuclear concerns: Committee on Armed Services

— general regulation of the nuclear industry: Committee on Interior and Insular Affairs

— nuclear export questions: Committee on International Relations

— research and development: Committee on Science and Technology

— facilities regulation and oversight: Committee on Interstate and Foreign Commerce.

On the Senate side, reform proposals made the following changes:

— national security aspects of atomic energy: Committee on Armed Services

— nonmilitary environmental regulation and control of atomic energy: Committee on Environment and Public Works

— international aspects, including nuclear transfer policy: Committee on Foreign Relations

— organization and management of U.S. nuclear export policy: Committee on Governmental Affairs

— energy policy: Committee on Energy and Natural Resources.

Radiation protection activities other than those pertaining to nuclear power are covered in two ways: by the Committees with jurisdiction over substantive areas like health or the environment, and by the Appropriations Subcommittees for each agency involved. Enumerating the responsibilities of each substantive Committee would not be helpful to people seeking pertinent hearings, since virtually every Committee has some possible angle on radiation protection: transportation, consumer products, occupational safety, small business, executive branch jurisdiction, and so on. Much depends on whether Members of a particular Committee are interested in radiation protection; if they are, they can find good reasons for exploring it.

• Executive Branch

Nearly everything the Federal government does in radiation protection is accomplished by the Environmental Protection Agency's Office of Radiation Programs (EPA/ORP), the Nuclear Regulatory Commission (NRC), FDA's Bureau of Radiological Health (BRH) and Bureau of Drugs, the Energy Research and Development Administration (ERDA), or the National Cancer Institute. The remaining activities and responsibilities are scattered among many agencies, including the National Bureau of Standards, the Occupational Safety and Health Administration, the Office of Telecommunications Policy, and the Central Intelligence Agency. While the discussion which follows is by no means complete, it does show the division of jurisdiction among four of the major agencies involved, and the way a number of multi-agency functions are handled.

Originally, nearly all authority pertinent to radiation protection was or is derived from the Atomic Energy Act and the Public Health Service Act. These basic statutes have been amended many times over and supplemented by Executive Orders; additional relevant laws have been passed, such as the Medical Device Amendments and the Consumer Product Safety Act.

Environmental Protection Agency (EPA)

When EPA was formed in 1970 (by Reorganization Plan No. 3), its new jurisdiction included that of:

— the Federal Radiation Council, a Presidentially appointed, Cabinet level group formed "to advise the President with respect to radiation matters, directly or indirectly affecting health, including guidance to Federal agencies in the formulation of radiation standards..." (73 Stat 690).

— radiation protection activities of the Department of Health, Education, and Welfare covered under the Public Health Service Act, except "insofar as the functions...pertain to (A) regulation of radiation from consumer products, including electronic product radiation, (B) radiation as used in the healing arts, (C) occupational exposures to radiation, and (D) research, technical assistance, and training related to clauses (A). (B), and (C)" (Reorganization Plan No. 3 of 1970, Section 2). Other functions under this Act involve research and investigation, national health surveys and studies, and Federal/State cooperation in public health.

— the Division of Radiation Protection Standards in the Atomic Energy Commission, "to the extent that such functions of the Commission consist of establishing generally applicable environmental standards for the protection of the general environment from radioactive material. As used herein, standards mean limits on radiation exposure or levels, or concentrations or quantities of radioactive material, in the general environment outside the boundaries of locations under the control of persons possessing or using radioactive material" (Ibid.).

Since 1970, EPA's radiation protection authority has been extensively supplemented. The major area of jurisdictional conflict resulting from the additional legislation has been implementation of water quality effluent limitations under the Water Quality Control Act of 1972. The Supreme Court found on June 1, 1976 that EPA is not required to regulate radioactive effluents in discharge permits for nuclear power plants (see below for a fuller discussion). Before that decision, in January 1976 a new and updated Memorandum of Understanding became effective between EPA and NRC on the preparation and evaluation of environmental impact statements. For all activities covered under the Water Quality Act of 1972:

1. NRC serves as the "lead agency" for preparation of environmental statements.
2. NRC and EPA work together to identify environmental information needed to evaluate the impact on water quality and biota.
3. EPA evaluates such impacts as far as possible in advance of the issuance of NRC's Final Environmental Impact Statement.
4. EPA endeavors to issue, where appropriate, a complete Section 402 permit under the National Pollutant Discharge Elimination System (NPDES) as far as possible in advance of the NRC licensing action (construction permit, operating license, or early site approval).
5. EPA and NRC consider the feasibility of holding combined or concurrent hearings on EPA's proposed Section 402 permits and NRC's proposed licensing actions.

The range of other additional legislation is extremely broad, since almost all of the major bills affecting EPA can include radiation protection in one way or another. Below are some of the most important:

— *Toxic Substances Control Act*, regulating all aspects of hazardous chemical substances and mixtures, including premarket review.

— *Resource Conservation and Recovery Act*, identifying and listing hazardous wastes, applying standards to their generators and transporters, issuing permits for treatment, storage or disposal.

— *Solid Waste Disposal Act*, publishing guidelines for solid waste systems, consulting with agencies which issue disposal licenses or permits.

— *Safe Drinking Water Act*, promulgating drinking water regulations, acting on an emergency basis to protect public health under certain conditions.

— *Clean Air Act*, publishing a list of air pollutants and issuing air quality criteria and standards for each pollutant listed, publishing categories of stationary sources and regulating them, publishing hazardous air pollutants and prescribing emission standards.

— *Marine Protection, Research and Sanctuaries Act*, allowing permits to be issued for ocean dumping of radioactive substances under certain conditions.

Nuclear Regulatory Commission (NRC)

Broadly speaking, the Atomic Energy Commission was split into its promotional (ERDA) and regulatory (NRC) parts by the Energy Reorganization Act of 1974 (88 Stat 1233, PL 93-438). NRC became responsible for the "licensing and regulatory functions" relating to commercial nuclear facilities, and to some facilities of the promotional arm (ERDA). Therefore, NRC must implement radiation protection standards, both by defining specific requirements in the licenses of individual plants and by enforcing them.

The other major area of NRC responsibility is the regulation of:

— "source material," meaning uranium or thorium, or ores of a certain concentration of either or both;

— "by-product material," meaning any radioactive material (except below) yielded in, or made radioactive by, producing or using special nuclear material;

— "special nuclear material," meaning plutonium, uranium-233, uranium enriched in the isotope 233 or 235, any material enriched by the foregoing, and any other material designated by the NRC. As will be seen below, much of the regulating of these materials is actually carried out by the States rather than by the NRC itself.

Energy Research and Development Administration (ERDA)

As the agency designated to take over the AEC's promotional functions, ERDA is responsible for the great bulk of research on the biomedical, environmental, physical and safety aspects of nuclear and other kinds of energy. While other agencies have a few projects in health effects of radiation, ERDA's program is extensive and comprehensive. It is also responsible for radiation health and safety and environmental protection at ERDA owned facilities.

Bureau of Radiological Health (BRH)

The Food and Drug Administration's BRH has many general public health responsibilities associated with radiation protection. It conducts an electronic product radiation control program, including the development and administration of performance standards. As the agency primarily responsible for radiation used in the healing arts, the Bureau develops criteria, recommendations, and standards relative to radiation use and exposure, as well as developing improved techniques, procedures and users' qualifications for reducing unnecessary exposure. BRH also provides advice to the Bureau of Foods and the Bureau of Drugs on the control of radioactive materials and radiation in food and drugs. Other functions include research, technical assistance and training in occupational radiation exposure; research on health effects of radiation exposure; and participation in the development of model codes and recommendations.

Multi-Agency Responsibilities

Occupational Exposure

The Occupational Safety and Health Administration (OSHA) covers workers who are exposed to radiation and not already protected by another agency. All Federal agencies are required to meet OSHA standards for their own employees, and to ensure that contractor employees are similarly protected. As part of its inheritance from the Federal Radiation Council, EPA is responsible for general Federal guides for occupational exposure, while BRH traditionally has covered health workers. For uranium, phosphate and other miners, the Mining Enforcement and Safety Administration (MESA) in the Department of the Interior sets health and safety standards within EPA guidance, which include regulation of exposure to radon and radon daughters.

Nuclear Export Licensing Policy

While NRC has responsibility for final decisions about licensing export of nuclear materials and equipment, a 1976 Executive Order (E.O. 11902, February 2, 1976) defines procedures for involving other agencies. They apply to specific export license applications, general licenses for export, and proposed exemptions from the requirement for a license. To produce an executive branch position on the effect on the common defense and security, the Secretary of State is to consult with the Secretaries of Defense and Commerce, the ERDA Administrator, and the Director of the Arms Control and Disarmament Agency.

Radioactive Materials Transportation

NRC, the Department of Transportation (DoT), the U.S. Postal Service, and the States all have a part in regulating the safety of commercial shipments of nuclear material. NRC regulations apply to its licensees and generally specify procedures and standards for packages and shipments. DoT regulates certain types of packaging, labeling and conditions of carriage. Since DoT and NRC jurisdictions overlap, the agencies operate under a Memorandum of Understanding in order to provide consistent, comprehensive and effective regulation without duplication. The Postal Service regulates shipments of nuclear materials by mail, and the States have regulatory authority over intrastate transport of nuclear materials.

Consumer Products

Jurisdiction over consumer products containing radioactive material is incomplete and extremely complex. Five different Acts may be used to regulate risks associated with products: the Occupational Safety and Health Act (by OSHA), the Atomic Energy Act of 1954 (by NRC or Agreement States, discussed below), the Clean Air Act (by EPA), or the Radiation Control for Health and Safety Act (by BRH).

If none of these can adequately reduce or eliminate the risk -- and if the radioactive substance involved is not regulated by NRC -- the Consumer Product Safety Commission may act. It can require appropriate branding and labelling of products containing radioactive substances, as long as it determines that the material is sufficiently hazardous to warrant control.

Emergency Response Planning

The Federal effort to develop and improve emergency response planning for radiological incidents includes provisions for assistance to State and local governments in making plans for fixed facilities and transportation. Led by the NRC, agencies involved include EPA, ERDA, DoT, HEW, the Defense Civil Preparedness Agency, and the Federal Disaster Assistance Administration. Responsibilities among them are assigned by the Federal Preparedness Agency of the General Services Administration; the current division was published in the *Federal Register* on December 24, 1975.

• Federal/State Jurisdiction

While the States may not regulate, control or restrict any NRC activities, they can and generally do regulate x-ray facilities and use, as well as radioactive materials not controlled by NRC. Forty-eight States and Puerto Rico have their own enabling acts for radiation protection, and 21 have specific statutes to control nonionizing radiation. In addition, although Federal radiation control authorities dominate the field and generally preempt States, many statutes include provisions permitting Federal authority to be delegated to States through individual agreements. Two of the most important laws with such provisions are the Atomic Energy Act and the Federal Water Pollution Control Act (FWPCA).

The Atomic Energy Act (as amended by Section 274) authorizes NRC to relinquish to a State its regulatory authority over by-product, source and special nuclear materials not sufficient to form a critical mass. As of the end of fiscal year 1976, there were 25 Agreement States exercising regulatory jurisdiction over approximately 10,700 "agreement material" licenses, as compared to about 8,500 such licenses administered directly by the NRC. As required by the Act, NRC conducts an annual formal review of State programs to assure continuing compatibility. NRC also provides training courses; exchanges current information on regulations, licensing, inspection and enforcement; and consults with State officials.

Similarly, EPA has agreements with 27 "permitting States" under FWPCA. They were contacted in March 1976 by the National Governors'

Conference to promote early cooperation with NRC in licensing nuclear power plants and related facilities. Suggesting that States might enter into agreements modeled after the principles of the NRC/EPA Memorandum of Understanding (discussed below), the Conference stimulated favorable response from nine States.

To help make State programs compatible and to some degree uniform, the Council of State Governments published *Suggested State Regulations for the Control of Radiation* in cooperation with Federal agencies. Those responsible for helping with periodic revision and updating are NRC, BRH, EPA, and particularly the Conference of Radiation Control Program Directors.

NATURALLY-OCCURRING RADIOACTIVE MATERIALS

1. Introduction and Summary

Most Americans are exposed to about the same magnitude of radioactivity from naturally-occurring sources, including cosmic rays, materials originating beneath the earth's crust, and a small amount from radioactive gases in the air. However, there are significant variations in exposure because of high concentrations of uranium, thoron and their decay products in soil; also, cosmic radiation varies considerably with land elevation and altitude above sea level. Exposure may also differ in accordance with individual lifestyles — because of more air travel, for instance.

One of the most important naturally-occurring sources of exposure is mined and processed ores originating in strata containing significant concentrations of uranium, thorium and their daughter products. As long as they are confined deep in the earth, the ores have little impact on people because of the shielding effect of the ground cover. However, when they are mined, separated, processed into consumer products and distributed, potential exposure to the population is increased. While people of course do not cause the natural radioactivity in the ores, they can increase and concentrate it by technological processes. Some of the industries where this takes place are phosphate, rare earth and several other mining concerns, as well as newer and less developed processes such as geothermal power production.

Radioactive substances can affect people and their environment through four basic pathways:

— as gases and particulates which are released to the air, becoming available for possible human inhalation and lowering the overall air quality.

— as materials in ores or the associated byproducts which may enter ground and surface waters by effluent discharges, land runoff, and leaching from waste piles.

— from close contact between workers and radioactive materials throughout mining and processing.

— from radioactive materials that have entered the food chain.

Because naturally-occurring radioactive materials have the potential for exposing large portions of the population, Federal agencies are extensively involved in identifying and assessing the public health and environmental problems associated with its various sources. Substantial problems have emerged, and analyses of new technologies are only beginning.

Summary

Congress enacted two major laws affecting naturally-occurring sources of radiation exposure: the Toxic Substances Control Act and the Resource Conservation and Recovery Act (summarized below). There was no significant court action.

Arranged by source of radiation, highlights of executive branch activities follow:

— Uranium mining and milling: NRC began preparing a Generic Environmental Statement on uranium milling operations, and continued to review license applications on a case by case basis. Several related Environmental Statements were considered, and EPA's Office of Radiation Programs (EPA/ORP) and NRC conducted relevant studies.

— Inactive uranium mill tailings sites: An engineering assessment of 23 inactive piles was continued by ERDA as part of a joint study with EPA.

— Non-nuclear energy sources: EPA/ORP continued compiling an annotated bibliography on radioactivity in fossil fuels. Assessments and surveys of coal as a source of radioactive emissions proceeded with particular emphasis on coal-fired power plants using Western coal. Studies were completed on radiological effects from radon in Liquefied Petroleum Gas and from geothermal energy.

— Mineral extraction industry: EPA/ORP continued to provide assistance to Florida in surveying the phosphate industry problem, and started to look at the radiological impact of (1) uranium recovery from phosphoric acid, and (2) fertilizer utilization. Also, a preliminary assessment of the copper industry was launched.

— Water: New Drinking Water Regulations were promulgated by EPA/ORP in July, and studies on radium removal began, along with evaluation of the potential health significance of radon in potable water.

— Construction materials: EPA/ORP began looking at the exposure levels in laboratory structures built with by-product gypsum, and sponsored a Harvard study of the effects of building materials on population dose equivalents.

— Other sources: EPA/ORP recommended that the National Park Service use the occupational exposure standard for uranium miners as guidance for its employees at caves such as Carlsbad Caverns.

2. Major Congressional and Judicial Activities

In 1976, Congress passed two major pieces of legislation applying to exposure from naturally-occurring radioactive materials, the Toxic Substances Control Act and the Resource Conservation and Recovery Act.

Toxic substances legislation has been considered for several sessions, but previously the House and Senate versions differed too greatly to compromise. Finally, on October 12, 1976, the Act was signed into law (PL 94-469), specifically excluding "any source material, special nuclear material, or by-product material (as such terms are defined in the Atomic Energy Act of 1954 and regulations issued under such Act)" [Section 3 (2)B(iv)].

However, the Toxic Substances Control Act does apply to naturally-occurring radioactive substances. If the Administrator of EPA "finds that there is a reasonable basis to conclude that (they)...present or will present an unreasonable risk of injury to health or the environment" [Sec. 6(a)], then he or she is to improve requirements to protect against the risk. Specifically, some of the rules which may be promulgated are:

— prohibiting or limiting the manufacture, processing or distribution of the substance;

— requiring that it be clearly marked with warnings and instructions;

— requiring that manufacturers and processors keep certain records.

The Act also has provisions for protection against imminent hazards, reporting of information, exports, preemption, citizens' civil actions, and administration.

The other important measure related to naturally-occurring materials is the Resource Conservation and Recovery Act of 1976 (PL 89–272). Signed into law on October 21, 1976, the Act amends the 1965 Solid Waste Disposal Act, which had already been strengthened somewhat by the 1970 Resource Recovery Act. Applicable provisions require the Administrator to define and identify hazardous wastes and issue regulations setting safety standards. The Act covers recordkeeping, storage, labeling, reporting and disposal; in addition, it authorizes some inspection, establishes civil penalties, and defines a relationship with the States.

There was no significant court action in this area in 1976.

3. Executive Activities by Source of Radiation

• Uranium Mining and Milling Tailings

The uranium in the ore extracted by mining is separated and concentrated in milling operations, which result in the accumulation of large quantities of waste product material called tailings. Composed primarily of ore residues, they contain almost all of the radioactivity that was originally present in the ore. Tailings are a waste management problem because of the large quantities involved, and because of the long half-life of the radionuclides.

As an indication of quantity, a typical mill may generate 1,800 metric tons per day of tailings solids slurried in 2,500 metric tons of waste milling solutions. Over the lifetime of the mill, 100 to 200 acres may be permanently committed to store this material. The tailings piles will have a radiological impact on the environment (1) through the air pathway by continuous discharge of radon-222 gas (a daughter of radium-226), (2) through gamma rays given off by radium-226, radon-222 and daughters as they undergo radioactive decay, and (3) finally through air and water pathways, if radioactive particulates are blown off the pile by wind or radionuclides are leached from the pile due to water seepage.

Solids are being stored at mills by constructing a dike and filling the diked area with slurried tailings. Some of the older mills and all new mills use a clay-core retention dam and various kinds of seepage return systems to control seepage from the tailings ponds. However, in addition to creating a pile which is difficult and costly to stabilize, the dikes are subject to the possibility of structural failures such as the one at the United Nuclear Homestake Partners Mill in New Mexico in 1976.

Uranium mill tailings piles contain long half-life radioactive wastes, and therefore require long-term care. This should include fencing, posting, monitoring, inspection and continual maintenance to assure integrity of the stabilizing cover.

As of December 1976, 16 uranium mills were in operation, all located in Western States. (See Table 2.1.) Eight of these mills are regulated by NRC, and eight are licensed under the Agreement States program. The various active mill sites already contain over 100 million tons of tailings. There are also a number of new mills presently under construction or in the planning stage. It is estimated that, by the year 2000, between 68 and 228 uranium mills may be in operation and 1 to 1.5 billion tons of uranium mill tailings will have been generated, covering an area from 30 to 70 square miles.

In non-Agreement States, NRC evaluates uranium milling operations and the conditions of mill tailings piles. This activity includes reviews of uranium mill licenses to evaluate the adequacy of the supporting information in the license files; on-site visits to determine the adequacy of uranium mill inspections; observation of the condition of stabilized and unstabilized mill tailings piles; and reviews of the licensees' environmental surveillance programs.

After an operating license is terminated, the owner of the land on which the tailings are stored is subject to the following NRC restrictions:

1. The holder of the land will not permit the release of tailings materials to the surrounding area.

2. Subdivision of the covered surface will be prohibited, including private roads, trails, or rights-of-way.

3. No structures that could be inhabited by people or animals may be built on the covered surface.[1]

Guidance/Environmental Impact Statements

Generic Environmental Statement

In March 1975 NRC received a petition for rulemaking from the Natural Resources Defense

TABLE 2.1 STATUS OF ACTIVE URANIUM MILL SITES IN THE UNITED STATES AS OF DECEMBER 1976
(16 active--2 active standby)

State	Location	Name and/or Owner	Year Mill Started	Nominal Mill Capacity (Tons Ore per Day)	Tons of Tailings (In millions)	Reported Size of Tailings Pile (Acres)
*Colorado	Canon City	Cotter Corporation	1958	150-450	1.1	35
	Uravan	Union Carbide Corp.	1950(a)	0-1300	7.0	80(c)
*New Mexico	Ambrosia Lake	Kerr-McGee Nuclear	1958	3600-7000	25.4(b)	200(c)
	Blue Water	Anaconda Company	1953	3000	15.3(b)	250(c)
	Grants	United Nuclear-Homestake Partners	1958	1650-3500	18.7(d,b)	150(f)
	Moquino	Sohio	1976			
South Dakota	Edgemont(e)	TVA (Mine-Development, Inc.)(e)	1956	250- 500	2.000	82
*Texas	Falls City	Conoco & Pioneer Nuclear, Inc.	1971	220-1750	2.600	200
Utah	La Sal	Rio Algom Corporation	1972	500	.74	45
	Moab	Atlas Corporation	1956	800-1500	7.8	120
*Washington	Ford	Dawn Mining Company	1957	0- 400	1.9	100
Wyoming	Gas Hills	Federal American Partners	1959	500- 950	4.0	100
	Gas Hills	Utah International, Inc.	1956	750-1200	5.5(b)	135
	Gas Hills	Union Carbide Corporation	1960	1000	4.0	61
	Jeffrey City	Western Nuclear, Inc.	1957	400-1200	3.0	60
	Powder River Basin	Highland Mill, Exxon, U.S.A.	1972	2000	2.2	250
	Shirley Basin(e)	Petrotomics Company(g)	1962	525-1500	4.5(b)	50
	Shirley Basin	Utah International, Inc.	1971	1200	1.8(b)	250

(a) Ore processed at the Vanadium facility for the Manhattan project in 1943.

(b) Estimated.

(c) Estimated from topographic map of site.

(d) Includes 1,200,000 tons from salvaged Homestake-New Mexico Partners Mill that was located on the present active site.

(e) Although the site license is still active, there is no present milling activity.

(f) Designated impoundment area.

(g) Mill will reopen January 1, 1978, and handle about 1,600 tons per day.

*Agreement States which have responsibility for licensing the mills. All others are licensed by NRC.

Council (NRDC). The petitioners requested that the Commission issue regulations requiring uranium mill operators to post performance bonds that would cover the cost of stabilizing and ultimately disposing of uranium mill tailings. They also asked the Commission to prepare a Draft Environmental Impact Statement on the NRC's uranium milling regulatory program, including that part administered by the Agreement States. The NRDC further petitioned that no licenses be issued or renewed while the Statement was being prepared, so licensees could not escape any new regulations promulgated as a result.

On June 3, 1976, the Commission announced its intention to prepare a Generic Environmental Impact Statement (GEIS) on uranium milling operations. The purposes of the GEIS will be:

1. to assess the local, regional and national environmental impacts of uranium milling on both a short and long term basis;

2. to provide a basis for deciding whether additional regulatory requirements are needed for uranium mills, with emphasis on the waste management of mill tailings;

3. to support any rulemaking and/or modification of statutory authorities which may be determined to be necessary; and

4. to provide an opportunity for public participation in decisions concerning any proposed changes in NRC regulations or regulatory authority.

During preparation of the GEIS, which has begun, the NRC will review applications for new or renewed licenses for uranium milling on a case by case basis; also, it will continue to assure that adequate financial security arrangements are made for the reclamation and stabilization of mill tailings. Any licensing actions may later be revised in accordance with the conclusions of the final GEIS and related rulemaking.

The decisions to prepare a Generic Environmental Impact Statement and to continue processing related applications in the interim, subject to specified criteria, were a partial response to the NRDC petition. Decisions on other aspects of the petition -- such as regulations covering financial responsibility for waste management over the long term -- had not been reached at year-end. The Commission intends to publish proposed rules for public comment no later than the final GEIS. (Such rules will be developed from the information derived from the preparation of the Statement and from an assessment of alternatives.)

Sherwood Uranium Project, Spokane Indian Reservation

Description: The Sherwood Uranium Project[2] involves construction and operation of a Western Electric facility which would mine and process about 7,950,000 tons of ore. The project site is leased from the Spokane Indian Tribe, which would get at least 50% of the available jobs. Among the possible environmental impacts discussed are the effects on ground water of treated liquid effluents, the need for revegetation, airborne radiological effluents, and release rates from the tailings pond.

EPA/ORP Response and Status: EPA/ORP's comments on the Draft Statement expressed concern about the management of overburden and tailings material, and requested that alternatives to the mill tailings retention system be presented in the Final Statement. One possibility suggested was re-emplacement of the tailings in the mine pit. In considering alternatives, EPA/ORP said that some additional studies might have to be made of local hydrology and groundwater characteristics.

Studies

NRC Task Force

NRC's research program to provide data for the GEIS and associated rulemaking will mainly involve: (1) an assessment of the public health and environmental impact of uranium milling operations with emphasis on mill tailings, and (2) identification and development of alternative strategies for mill tailings waste management, including assessment of their practicality and costs.

The NRC has asked a 13-member task force to develop information from which acceptable methods for handling and storing tailings can be devised. It will examine current procedures for handling tailings and for choosing waste storage sites, and will identify areas where further research is needed to form the basis for regulatory requirements. Members of the task force represent several scientific disciplines and a number of private and governmental institutions including EPA. The report is being prepared by Argonne National Laboratory.[3]

EPA/ORP Study of In-situ Mining

EPA/ORP began investigating the radiological aspects of in-situ mining of uranium, an experimental technique being assessed in ore bodies of limited size and uranium concentration. It is hoped that the process would eventually produce saleable yellowcake onsite, as opposed to the highly impure product which now has to be processed at a conventional mill.

Ambrosia Lake Study

EPA/ORP released in June the results of a November 1975 study to determine the ambient radiological air quality in a region of active uranium ore mining and milling operations.[4] In the Ambrosia Lake area of New Mexico, there are three operating mills, one inactive mill, associated tailings ponds, and approximately 20 active underground mines contributing radon and radon progeny (as well as airborne particulate material) to the atmosphere. The EPA/ORP report presents measurements of ambient outdoor radon concentrations and indoor working level determinations for ten locations throughout the area. Further efforts will be made in 1977 to define the origins of excess radon levels more clearly as part of a joint Federal/State study in the Grants Mineral Belt area.

EPA/ORP Report on Environmental Impact

EPA/ORP released an April report, "Potential Radiological Impact of Airborne Releases and Direct Gamma Radiation to Individuals Living Near Inactive Uranium Mill Tailings Piles."[5] Identifying radon-222 and its daughter products as the most significant hazard to people living near the piles, the report described EPA/ORP's methods of assessing potential hazards and possible pathways. It was found that people living near the 23 inactive piles (averaging 35 acres) could be exposed when:

— radon-222 escapes from the surface of the pile and is carried to nearby dwellings by the wind;

— the wind lifts particles containing radionuclides from the surface, and they are inhaled;

— radionuclides in the pile emit gamma radiations.

• Inactive Uranium Mill Tailings Sites

During the past 28 years there have been more than 40 ore upgraders and mills that have produced uranium for sale to the government and private industry. Twenty-four of these mills in nine Western States have been closed, leaving the accumulated radioactive residues or tailings. Four of the sites are currently under active NRC or Agreement State licenses, and one site is maintained by the Federal Government. Twenty-three inactive mills (excluding the Federal site in Monticello, Utah) have tailings totaling 28 million tons with individual piles varying from 90,000 tons to 2.7 million tons (Table 2.2).[6]

Studies

Joint Engineering Assessment

ERDA continued its engineering assessment of 23 inactive uranium mill tailings piles as listed in Table 2.2, in the second phase of a joint comprehensive study with EPA. It includes evaluation of

TABLE 2.2

MILL SITES INCLUDED IN PHASE II STUDY

	Years Operated	Tons of Tailings
Arizona		
Monument	1955 - 1967	1,100,000
Tuba City	1956 - 1966	800,000
Colorado		
Durango	1943 - 1963	1,555,000
Grand Junction	1951 - 1970	1,900,000
Gunnison	1958 - 1962	540,000
Maybell	1957 - 1964	2,600,000
Naturita	1939 - 1963	704,000
New Rifle	1958 - 1972	2,700,000
Old Rifle	1924 - 1958	350,000
Slick Rock (NC)	1931 - 1943	37,000
Slick Rock (UCC)	1957 - 1961	350,000
Idaho		
Lowman	1955 - 1960	90,000
New Mexico		
Ambrosia Lake	1958 - 1963	2,600,000
Shiprock	1954 - 1968	1,500,000
Oregon		
Lakeview	1958 - 1960	130,000
South Dakota		
Edgemont	1956 - 1974	2,000,000
Texas		
Falls City	1961 - 1973	2,500,000
Ray Point	1970 - 1973	490,000
Utah		
Green River	1958 - 1961	123,000
Mexican Hat	1957 - 1965	2,200,000
Salt Lake City	1951 - 1968	1,700,000
Wyoming		
Converse County	1962 - 1965	187,000
Riverton	1958 - 1963	900,000
TOTALS		28,056,000

the problems and examination of the alternative solutions, the preparation of cost estimates, and detailed plans and specifications for alternative action measures. Any remedial action that may result from the study will require legislation and additional funds. A report on the site in Salt Lake City, Utah, was published in April 1976.[7]

Navajo Nation Studies

Since 1968, EPA/ORP has provided technical assistance and advice to the Navajo Nation on matters dealing with uranium mill tailings piles on their reservation. During 1976 EPA/ORP continued to provide technical assistance in decontaminating the Shiprock, New Mexico, inactive uranium mill site. Reports of assessments of several sites will be available in 1977.

• Non-Nuclear Energy Sources

Bibliography on Radioactivity of Fossil Fuels

To identify literature relevant to assessing radioactivity of fossil fuels, EPA/ORP is compiling an annotated bibliography[8] in four major subject areas: coal, oil, natural gas and shale oil. A fifth section deals with fossil fuels in general, focusing on performing radiological assessments of fuel utilization. Some of the findings to date include:

— *Coal*: Western coal having significant uranium content appears to occur only on a localized basis in low-grade coal deposits, most of which are not now being considered for active mining. Concerns about the possible radiological impact have arisen in part because coal mining in the West has steadily increased over the past few decades to its 1971 level of over 30% of total U.S. production. Coal originating in deposits with significantly elevated concentrations of uranium can affect the environment through airborne discharges, solid waste materials and ash utilization.

— *Other fossil fuels*: Literature compiled in non-coal areas is scarce, and the little there is provides limited data. No potentially hazardous levels for the general population were identified from these sources, although maximum concentrations of radon-222 in natural gas may be high for some individual users.

Coal

Radioactivity in coal used for power generation has received more attention since utilities have increased their use of Western coals, some of which contain more uranium than Eastern ones. The concentration of radium-226, one of the critical radionuclides, varies with ash content and many other factors; it generally averages about one pCi/g, although specific coal beds may contain a much higher concentration.[9]

Extensive surveys by the U.S. Geological Survey have shown that concentrations of uranium range as high as .1 percent in some mineralized lignite beds of North and South Dakota.[10] For unmineralized deposits, concentrations were similar to those found in Eastern coal types. In general, bituminous and lignite deposits contain more uranium than anthracite.

A well run coal-fired power plant releases a small fraction of the coal's total radioactivity in the form of fly ash, with some of the remaining ash handled in ways that could expose the public.[11] NRC has sponsored a generic study to collect available data and assess the public health and safety impacts of the coal fuel cycle.

Assessment of Radiological Impact of Western Coal

EPA/ORP cosponsored with ERDA and the Federal Energy Administration a study to determine whether there is a potential environmental problem due to radioactive emissions from coal-fired power plants using Western coal. The results, currently under final review, indicate that it does contribute quantities of various radionuclides to the environment. While no immediate population hazard has been found, a number of potential impacts have been identified. Further assessment appears to be called for to determine exposure levels due to lead-210 deposition, polonium emissions, and coal ash utilization.

Liquefied Petroleum Gas

EPA/ORP conducted an assessment of potential radiological health effects from the radon in Liquefied Petroleum Gas.[12] It was estimated that doses from unvented kitchen ranges and space heaters are low — about .9 and 4.0 mrem/year respectively to the bronchial epithelium — and that they would result in less than one lung cancer a year for the total U.S. population at risk. As control costs would be over $50 million, EPA/ORP concluded that they would not be cost effective on a population basis. Special cases of high individual exposure were still under study at the end of the year.

Geothermal Energy

EPA/ORP began sampling geothermal waters in the West in 1974 to characterize their radiochemical species and assess the possible radiological impact. The use of geothermal sources for generating electricity, or for providing direct space heating or industrial heat sources, does not create additional radioactivity, as does nuclear power. Rather, such activities concentrate and redistribute naturally-occurring radioactivity through the biosphere.

In 1976, preliminary results of EPA/ORP's analyses were reported in "Radioactivity Associated with Geothermal Waters in the Western U.S."[13] The report describes sample locations and techniques, and the results of the sample analysis. Data indicate radon concentrations as high as 14,000 pCi/liter and radium concentration up to 1,500 pCi/liter.

• Mineral Extraction Industry

Phosphate Mining & Milling

As long as naturally-occurring radioactive materials remain in the depths of the earth, they have little effect on people and the surface environment because of many feet of soil and rock. However, numerous industries mine, bring to the surface, and process raw materials containing significant concentrations of uranium, thorium and their daughter products.

The phosphate mining and manufacturing industry provides an example the problems that can result from redistribution of radioactive material in the surface environment. In central Florida alone, about 37 million tons of phosphate rock are processed each year (about 80% of U.S. production). The radiological impact is considerable, as shown in Table 2.3. It presents the results of EPA/ORP's analytic determinations of radium-226, uranium, and thorium concentrations in Florida's phosphate products and wastes.

One set of environmental and health impacts results from the production of phosphoric acid from marketable rock. The usual wet process method — used in 1974 to produce about five million tons of acid from 20 million tons of rock — involves the discharge of radium in liquid effluents, as well as significant concentrations of radium and thorium in products and by-products. (See Table 2.4 for details.)

Other problems stem from the fact that phosphate manufacture involves the accumulation of massive gypsum piles (30–100 feet in height) and the maintenance of large cooling ponds of waste (often about 500 acres). The production of elemental phosphorus results in radioactive air effluents from the thermal milling process, although most of the radioactivity originally in the phosphate ore can be found in the by-product slag.

Occupational Impact

Based on normal worker occupancy and radiation levels measured in Florida facilities, it has been estimated that direct gamma dose equivalents for workers in phosphoric acid or elemental phosphorus plants range from 30 to 300 mrem per year. The annual dose equivalent rate to the lung has been estimated to be as high as five rem/year for these workers. The major occupa-

TABLE 2.3

RADIUM – 226, URANIUM AND THORIUM CONCENTRATIONS IN FLORIDA PHOSPHATE MINE PRODUCTS AND WASTES (20)

MATERIAL	RADIUM – 226 (pCi/GRAM)	URANIUM (pCi/GRAM)			THORIUM (pCi/GRAM)			
		234	235	238	227	228	230	232
MARKETABLE ROCK	42	41	1.9	41	2.0	0.61	42.3	0.44
SLIMES	45	42	2.6	44	2.3	1.2	48	1.4
SAND TAILINGS	7.5	5.2	0.38	5.3			4.2	89

TABLE 2.4

RADIUM – 226, URANIUM AND THORIUM IN WET PROCESS PHOSPHORIC ACID PLANT PRODUCTS AND BYPRODUCTS

MATERIAL	RADIUM – 226* (pCi/gm)	URANIUM (pCi/gm)			THORIUM (pCi/gm)			
		234	235	238	227	228	230	232
GYPSUM	33	6.2	0.32	6.0	0.97	1.4	13	0.27
NORMAL SUPER-PHOSPHATE	21			20			18	0.6
DIAMMONIUM PHOSPHATE (DAP)	5.6	63	3.0	63	1.6	0.8	65	0.4
TRIPLE SUPER-PHOSPHATE (TSP)	21	58	2.8	58	1.2	0.9	48	1.3
MONOAMMONIUM PHOSPHATE (MAP)	5.0	55	2.9	55			50	1.7
SODIUM FLOUROSILICATE	0.28			N.D.			N.D.	N.D.
ANIMAL FEED	5.5							
PHOSPHORIC ACID	<1			25			28	3.1

*PLANTS USING FLORIDA PHOSPHATE ROCK

tional hazards are in areas of high dust concentrations and in or around the phosphoric reactor vessel and its associated equipment. EPA/ORP sees a need for more prudent "good housekeeping" measures, particularly with respect to dust levels, but does not believe that Florida workers are being exposed at levels greater than the radiation protection guides for the general population (500 mrem/year).

EPA/ORP Studies

Another cause for concern is that reclaimed mining areas — where the soils contain substantially more radium than normal soil — are used extensively for residential and agricultural purposes. EPA/ORP worked to address these concerns in 1976 by continuing its assistance to the State of Florida in implementing a radiological survey of representative homes built on reclaimed land. Data collection was continued until a full year's exposure was available for study. Pending that data and formulation of final recommendations, EPA/ORP made these suggestions to Florida in 1975:

External Gamma Radiation Level	Recommendation
= or greater than 0.01 mR/hr	Construction should be delayed pending study or acceptable control technology should be instituted to preclude indoor radon daughter problems.
Less than 0.01 mR/hr.	Construction may be initiated.

In addition, EPA/ORP began sampling fruits (particularly citrus) and vegetables grown on reclaimed land, and data will be evaluated in 1977.

EPA/ORP initiated a contract to assess the radiological impact of uranium recovery from phosphoric acid, an innovative technique which is now being commercialized. It uses solvent extraction of uranium from the phosphoric acid process stream; it holds great promise not only as a source of uranium, but also as a measure to reduce the amount of uranium released to the environment through fertilizers and other phosphate products and wastes.

Although the phosphate mining and milling industry was the first selected for concentrated effort by EPA/ORP, other mineral extraction industries also have a potential for contributing to occupational and public radiation exposure. Ores such as copper, titanium and beryllium, depending upon mine location, have shown uranium concentrations high enough to be commercially extractable, especially as the price of uranium rises.

Egyptian Phosphate Industry Study

EPA/ORP decided to support, under the Special Foreign Currency Program, an evaluation by the University of Alexandria, Egypt of the phosphate mining and manufacturing industry. It will cover the industry's radiological impact, particularly with respect to underground phosphate mining and airborne emissions from manufacturing facilities. It is hoped that evaluation of the Egyptian industry will contribute to an understanding of the radiological impact of its American counterpart.

Egypt was chosen for the project because:

— the literature indicates that the concentrations of uranium and radium in Egyptian phosphate samples are about 120 ppm and 40 pCi per gram, respectively, which are similar to U.S. ore.

— the industry is expanding greatly in the next few years. Plans for a new phosphoric acid plant have been completed and construction will begin soon; facilities are also being built to increase the phosphate concentration of the marketable ores.

— large numbers of people will be exposed to elevated levels of radioactivity. More than 10,000 workers are involved, including miners who work in mines with only natural ventilation, where radon decay products may build up. Moreover, a number of phosphate facilities are located near towns and cities where dust and other atmospheric emissions may result in exposure to many nearby residents.

Radiological Aspects of Fertilizer Utilization

About 80 percent of the phosphate rock mined and consumed in the U.S. is used for the manufacture of fertilizers, which contain concentrations of different radionuclides varying with production processes. EPA/ORP completed a study of the overall potential health impact of fertilizer use due to increased radioactivity in crops. After measuring the amounts of radium-226, thorium and uranium in samples of various fertilizers, doses were calculated on the basis of uptake information in the literature.

Copper Industry

During 1976, EPA/ORP performed a preliminary assessment of the copper industry to identify and delineate the magnitude of radiological impacts of mining and milling of uraniferous copper ore. Although a comprehensive survey of radioactivity has not yet been done, limited data is available from the U.S. Geological Survey, the Bureau of Mines and EPA/ORP.

As Figure 2.5 details, four areas of potential occupational and/or public radiation exposure have been identified. An effort was made to collect radiological data, when available, for each of these effluent pathways. Although gamma analyses of the ore bodies themselves show only approximate background radiation levels, elevated levels of uranium and decay products are evident in sampling of ore, copper leachate solutions and mine runoff water.

Radon measurements conducted by the Mining Enforcement and Safety Administration (MESA) in underground copper mines have also been significantly above background levels, exceeding 0.33 working levels (see glossary). For mine pumpout water, average radium-226 concentrations ranging from 1.5 to 27.3 pCi/1 were measured for operating mines in Michigan, Montana, and Arizona.

Other than a potential occupational exposure impact, the study concludes that there is no evidence at present that the copper industry constitutes a radiological public health hazard. Further field work is recommended, however, to quantify concentrations of uranium in mining and milling effluents more accurately, and to characterize occupational exposures in the industry.

• Water

Guidance

Radioactivity in Drinking Water

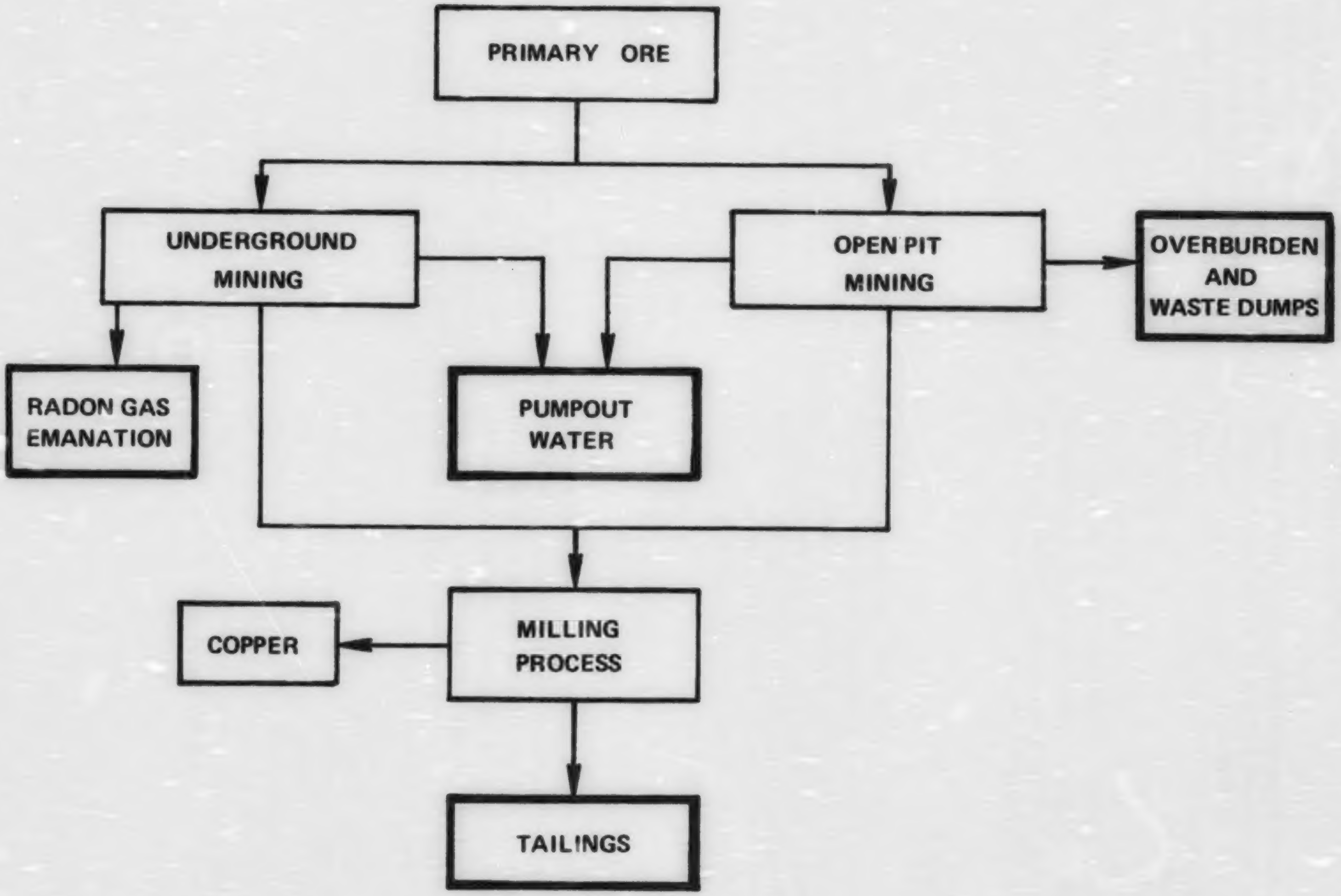
On July 9, 1976, EPA promulgated National Interim Primary Drinking Water Regulations[14] radioactive contaminants. The Regulation restricts the levels of natural and man-made radionuclides in community water systems, effective June 24, 1977. This regulation was in addition to previous Interim Regulations[15] on microbiological, chemical and physical contaminants.

For alpha contaminants, the Regulations provide that initial compliance sampling will begin within two years of the effective date, and will be completed within an additional year. Thereafter, monitoring shall be conducted not less than once every four years. Gross alpha particle activity measurements are used as a screen to determine the need for specific radium isotopic analyses. If the gross alpha particle activity exceeds a certain level (five picocuries per liter), analysis for radium-226 is required, and for radium-228 if the radium-226 activity exceeds three picocuries per liter.

Systems serving more than 100,000 persons from surface water supplies, and any other systems designated by the State, are required to analyze for gross beta activity and for tritium and strontium-90, within two years of the effective date, and at four year intervals thereafter. If the gross beta activity exceeds 50 picocuries per liter,

Figure 2.5

MAJOR EFFLUENT PATHWAYS FOR URANIUM IN COPPER MINING AND MILLING


PRIMARY ORE
UNDERGROUND MINING
OPEN PIT MINING
OVERBURDEN AND WASTE DUMPS
RADON GAS EMANATION
PUMPOUT WATER
MILLING PROCESS
COPPER
TAILINGS

the major constituents must be determined for calculation of organ and total body doses. Analysis for iodine-131 may be required by the State if the supply is contaminated by effluents from nuclear facilities. Environmental surveillance data from nuclear facility monitoring programs may be accepted by the State in lieu of direct monitoring of the water supply.

All measurements must be made by laboratories approved by the enforcing authority. Generally, States will have primary enforcement responsibility unless they do not request or achieve it, in which case it would rest with EPA. The principal radiological laboratory for each analysis in a State would be certified by a regional EPA team, supplemented by the Quality Assurance Branch of EPA's Environmental Monitoring and Support Laboratory, Las Vegas, Nevada.

Studies

Radium Removal Process

Numerous well-water supplies for public water systems contain naturally-occurring radium-226. Methods for removing radium from drinking water must be identified so that treatment plants may meet the limit set in the EPA drinking water regulations. Studies were performed by State agencies at 14 cities in Iowa and Illinois to determine the radium removal efficiency of four water treatment processes.[16] Populations served by the water treatment plants ranged from 235 to 24,000, and the radium-226 concentration in the raw water varied from three to 49 pCi/liter. Results showed radium removal efficiencies from 11 to 95 percent.

Radon in Potable Water

EPA/ORP began evaluating the potential health significance of radon-222's diffusing from potable water supplies inside structures. Present data indicate that one-third to one-half of all ground water supplies could have radon-222 concentrations greater than 500 picocuries (pCi) per liter. When this water is used in a home, especially with increased temperature and agitation, much of the radon could diffuse into the air.

Various literature articles were reviewed for relevant information. Initial considerations indicate that if water containing 10,000 pCi/liter radon-222 is used in a dwelling, an air concentration of one pCi/liter could occur. This might cause a bronchial epithelium exposure of 80 millirems/week (four rem/year), and an ingestion exposure of 25 mrem/week to the walls of the stomach. If water containing 500 pCi/liter radon is used across the U.S., it is estimated that 20 fatal lung cancers per year could result from inhalation of radon daughters for each million people exposed. EPA/ORP is continuing the evaluation of this source of exposure.

• Construction Materials

Elevated radiation levels from building material were discovered in Grand Junction, Colorado, where some structures are built on or adjacent to uranium mill tailings. The tailings were incorporated in either the fill, building material, or concrete. Because the radon daughter activity levels in many of the structures exceed the Surgeon General's guide, ERDA and the State of Colorado are conducting a remedial action program to reduce them.

Phosphate by-products interest EPA/ORP greatly, not only because of the sheer quantity involved — 50 to 300 acres of gypsum piled 50 to 100 feet high at an average plant — but also because of their radium-226 concentrations. Questions have been raised concerning the use of phosphate slag material in concrete blocks and pavement in Florida, Ohio, Idaho and a few other States. By-product gypsum is of special concern; it is commonly used in the manufacture of wallboard in other countries, although it has not been used commercially in the U.S. primarily because of abundant natural supply. Insulation is another potential difficulty.

Studies

To assess the exposure levels in structures built with by-product gypsum, EPA/ORP began a project using Japanese materials in a test structure, and started developing a model for calculation of internal doses due to radon emanation.

Also, under contract to EPA/ORP, Harvard University conducted a study of the effects of building materials on population dose equivalents. The initial purposes were:

— to search all published information on the subject,

— to develop a detailed model for estimating the dose equivalent rate to the inhabitants of buildings, and

— to estimate the dose equivalent to the U.S. population from building materials. A secondary part of the effort was to analyze ways to minimize such exposure, including cost/benefit analyses to identify which approaches should be studied further.

The study concluded that naturally-occurring radionuclides in building materials are a source of external and internal radiation exposure to virtually the entire U.S. population. The dose equivalent rate in a given situation is a complex function of the geometric distribution of radionuclides within a building, the air exchange rate, and the time utilization factor for each room. A computerized model, written in Fortran IV, has been developed for calculating dose equivalent rates, both for external and internal sources, to occupants in a building for a variety of assumed conditions.

• Other Sources

Carlsbad Caverns Recommendation

The National Park Service asked EPA/ORP for guidance on the appropriate exposure limits for park personnel, concessionaires, and visitors to the Carlsbad Caverns, following a radiation monitoring survey which showed radon daughter concentrations of up to 0.25 working levels (see glossary). EPA/ORP made interim recommendations[17] based on existing "Federal Guidance for the Protection of Underground Uranium Miners"[18] which recommends against cumulative exposures to employees in excess of four working level months in any calendar year. EPA/ORP decided that the guidance provided for employees is sufficient to protect all who visit the Caverns, and recommended continued sampling. Public comment was invited on applying this recommendation to other caves and caverns.

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ORP/LV 76–4
ORP/LV 76–7
ORP/LV 76–9
ORP/TAD 76–1
ORP/TAD 76–2
ORP/TAD 76–5

MEDICAL RADIATION EXPOSURE

1. Introduction and Summary

Medical exposure to ionizing radiation can and should be significantly cut without reducing quality of care, according to experts in the scientific community. As matters stand, over half of the U.S. population receives at least one radiographic examination annually, and medical exposures account for at least 90 percent of the total man-made dose to individuals.[1]

These trends have probably continued since 1970, especially the increase in film usage.

In 1971 the National Conference of Radiation Control Program Directors initiated the Nationwide Evaluation of X-Ray Trends (NEXT) to assess patient exposure from specific routine radiographic examinations. Analysis of data from this program indicates that the weighted mean exposure for nine of the 12 radiographic projections surveyed increased between 1973 and 1975.[3]

TABLE 3.1 **TRENDS IN RADIOGRAPHIC DIAGNOSTICS**

PERSONS X-RAYED	1964	108 MILLION
	1970	130 MILLION
X-RAY EXAMINATIONS	1964	173 MILLION
	1970	212 MILLION
FILMS EXPOSED	1964	506 MILLION
	1970	661 MILLION

The problem of unnecessary risks associated with medical exposure is compounded by the marked increase in the number of diagnostic examinations performed over the last decade, estimated to range from one to four percent per capita annually. Some significant changes were revealed in surveys of diagnostic x-ray exposures in 1964 and 1970:[2]

— There was a 20 percent increase in the number of persons receiving one or more x-ray procedures, from 108 million in 1964 to 130 million in 1970. The population increased only seven percent during this period.

— There was a 22 percent increase in the number of x-ray examinations performed, from 174 million in 1964 to 212 million in 1970.

— There was a 30 percent increase in the number of films exposed, from 506 million in 1964 to 661 million in 1970.

— The average number of films per radiographic examination increased from 2.2 in 1964 to 2.4 in 1970.

Among the scientific bodies who have reviewed diagnostic exposure issues is the Biological Effects of Ionizing Radiation (BEIR) Committee of the National Academy of Sciences. In its 1972 report,[4] the Committee concluded that as much as 30 percent of patient exposure is due to the use of less than optimal techniques, and that nearly ten percent of all exposure can be attributed to retake examinations. The Committee further expressed the view that "medical radiation exposure can and should be reduced considerably by limiting its use to clinically indicated procedures utilizing efficient exposure techniques and optimal operation of radiation equipment. Consideration should be given to the following:

1. Restriction of the use of radiation for public health survey purposes, unless there is a reasonable probability of significant detection of disease.
2. Inspection and licensing of radiation and ancillary equipment.

3. Appropriate training and certification of involved personnel. Gonad shielding (especially shielding the testes) is strongly recommended as a simple and highly efficient way to reduce the Genetically Significant Dose."

The Report also stated "that experts estimate that it appears reasonable that as much as a 50 percent reduction in the genetically significant dose (GSD) from medical radiology might be possible through improved technical and educational methods."[3] A study[4] by FDA's Bureau of Radiological Health (BRH) indicates that in 1970 the genetically significant dose was approximately 20 millirems per American; using the BEIR risk estimate, this could cause up to 543 serious health effects (genetically related). It appears that half of these, or 272, would be due to poor radiological practice.

Summary

This chapter describes efforts by a number of Federal agencies to address the issue of unnecessary exposure in both x-ray procedures and nuclear medicine treatments. A few highlights of each section follow:

• Major Congressional and Judicial Activity

While no new bills were passed in 1976, the first civil penalty was levied for failure to comply with regulations issued under the Radiation Control Act of 1968. The Sheppard X-Ray Company of Fairless Hills, Pennsylvania, signed a consent decree to pay a $2,000 fine.

• Comprehensive Executive Activities

BRH proposed regulations establishing procedures to exempt products for Government use from performance standards (promulgated under the Radiation Control for Health and Safety Act). Research was conducted on long-term radiation effects and childhood cancers.

• Conventional Diagnostic X-Ray Systems

Plans were announced to develop recommendations for quality assurance programs in diagnostic x-ray facilities.

A final voluntary recommendation endorsed the concept of appropriate use of specific area gonad shielding during diagnostic x-ray exams.

BRH published a technical overview of clinical methods of avoiding medical x-ray exposure of the human embryo and fetus, as an intermediate step in formulating a voluntary recommendation.

The BRH Medical Radiation Advisory Committee suggested a more restrictive policy on the use of mammography in screening. BRH is consulting with other health agencies and professional groups to develop a joint statement or guideline.

EPA and HEW (parent agency of BRH) negotiated a Memorandum of Understanding concerning guidance to Federal agencies on radiation protection in the healing arts.

An Interagency Working Group formed by EPA issued its final report on reducing unnecessary radiation exposure from x-rays in Federal health care facilities. From their recommendations, EPA published proposed Radiation Protection Guidance in that area.

Many educational programs were undertaken, including expansion of the services of the Radiological Health Sciences Learning Laboratory and extension of a series of training packages for radiologic technologists.

Quality assurance activities included the Dental Exposure Normalization Technique (DENT) and Breast Exposures: National Trends (BENT) programs. BRH is cooperating with the Conference of Radiation Control Program Directors in developing a quality assurance surveillance manual.

In the research area, the Nationwide Evaluation of X-Ray Trends (NEXT) continued, and studies were made of the bone marrow dose to adults from diagnostic radiography, organ doses, mammography risks and benefits, x-ray operator job performance, and skull x-ray selection criteria.

Corrective action programs covered both medical and dental x-ray units, and included assessment of quality control and testing programs.

BRH contracted with 18 States for compliance inspections of medical x-ray equipment as part of the Bureau's enforcement program under the Federal performance standard for x-ray equipment.

• Computered Tomographic Systems

BRH is considering modifying its safety performance standards to provide specifically for tomographic systems; in the meantime, however, it has notified manufacturers that they must heed present regulations or apply for an authorized deviation from them. Compliance action was taken in several cases.

Research on panoramic dental units showed substantial variation in internal exposures to patients, although all were low.

• Nuclear Medicine

BRH developed several new educational tools: a manual on quality assurance for scintillation cameras, and a course on instructional techniques for radiation protection.

The latest concepts of internal dosimetry were discussed at a BRH sponsored symposium, and a contract was awarded to develop quality assurance workshops.

1976 studies in the field included one on childhood exposure to iodine-131 and another on scintillation camera image quality.

One accident is discussed, in which about 400 patients taking cobalt-60 teletherapy treatment received doses over the prescribed amounts.

The Task Force on Short-Lived Radionuclides for Medical Use reviewed preliminary reports on modifying radioiodine policies, and on the consequences of several alternatives. Another Task Force, on the public health impact of nuclear medicine practice, began reviewing existing data sources and evaluating their potential contribution to developing reliable estimates on practices and trends.

• Cabinet X-Ray Systems

BRH prepared a document describing routine compliance testing for cabinet systems, and established automatic data processing systems to maintain a current list of the locations of units and to analyze results of field tests.

• Ultrasound

New proposed safety performance standards for ultrasonic therapy and surgery equipment were issued by BRH in June. A panel of scientists and technical experts was convened to review BRH's research efforts on ultrasound bioeffects and measurements.

2. Major Congressional and Judicial Activities

Congressional activity was confined to consideration of the Senate version of the Health Professionals Educational Assistance Act of 1976, which would have provided for the training and licensing of radiologic technicians. (A new Title XVI would have been added to the Radiation Control for Health and Safety Act to this effect.) However, the Conference Committee adopted the House version of the Act instead, and it had no similar provision.

Judicial activity included the first civil penalty levied for failure to comply with regulations issued under the Radiation Control Act of 1968. The Sheppard X-Ray Company of Fairless Hills, Pennsylvania, signed a consent decree to pay a $2,000 fine for failure to certify and report the assembly of certified components into diagnostic x-ray systems, as required by the Federal diagnostic x-ray equipment performance standard. Under the enforcement provisions of the Act, United States District Courts are authorized to restrain violations of promulgated regulations and to punish violators through the imposition of civil penalties of up to $1,000 for each infraction. Following a pretrial hearing, Sheppard decided to sign the consent decree rather than contest the case in court, and agreed to comply with the regulations in future.

3. Executive Activities Pertaining to Public Exposure

• Comprehensive Activities

Guidance

Exemption Procedures for Government Used Products

After consulting with other agencies on its 1975 version, BRH issued a revised proposal[7] to establish procedures for exempting products for Government use from performance standards promulgated under the Radiation Control for Health and Safety Act.

The original version[8] stipulated that the product manufacturer would be required: (1) to apply for the exemption, and (2) to demonstrate both the need for it and the extent to which the product could meet the criteria set forth in the applicable standards. The major changes in the reissued proposal permit either the manufacturer or the procuring agency to apply for the exemption, and provide guidance for communication between the agency and the Bureau whenever the need for an exemption is anticipated. In addition:

— administrative procedures are prescribed for exemption of products intended for Government use only, for purposes of research, investigation, study, demonstration, or training; or for national security reasons; and

— the Bureau's Director may impose terms or conditions on an exemption that may include specifications related to manufacture, use, control, or disposition of exempted products.

Education and Quality Assurance

Training Resources Center

BRH's Training Resources Center distributed its updated "Radiological Health Training Resources"[9] extensively in 1976, filled 582 requests for fascicles, manuals, or books; and loaned 160 slides or overhead projects, 143 movies, and 778 videotapes. Videotapes are now being used to train BRH Regional Representatives, State personnel and users of x-ray equipment, with subjects ranging from the Bureau's mammography quality assurance program to bioeffects of ionizing radiation and cardiovascular nuclear medicine.

Studies

Long Term Radiation Effects

Under contract to BRH, the Collaborative Radiological Health Laboratory of Colorado State University continued a study of the lifetime hazards associated with prenatal and early postnatal ionizing radiation exposure in the beagle. An ad hoc group of experts met in March 1976 to review the status of the project, which has already made about 100 contributions to the published scientific literature.

Oxford Study of Childhood Cancers

BRH continued its sponsorship of analyses of the Oxford Survey of Childhood Cancers, which is an epidemiologic investigation of children in Great Britain who died of leukemia or other childhood cancers. The study began in 1953 with children who died under ten years of age, and has since been expanded to include children under 15 years of age in order to encompass the long latent periods of cancer. The survey includes over 10,000 children who died of cancer and a comparable group of surviving children, and now focuses primarily on prenatal x-ray exposure.

Polish Radiation Bioeffects Studies

Under the Special Foreign Currency Program, three Polish radiation bioeffects studies were approved on:

— effects of gamma irradiation on lymphocytes,

— structure and photochemistry of nucleic acid analogues, and

— biological properties of melanins.

Uranium in Dental Porcelain

A BRH study found that the radiation doses due to the uranium used in dental porcelain appear to present no significant hazard to denture wearers or to exposed workers. Uranium is added to dental prostheses because no other substance has been found to equal its imitation of the fluorescence of natural teeth under all lights.

• Conventional Diagnostic X-Ray Systems

Guidance

Quality Assurance Recommendations

BRH announced plans to develop recommendations for quality assurance programs in diagnostic x-ray facilities. The Bureau's experience with quality assurance activities, which dates back to the early 1970's, and its consultations with others, have indicated that voluntary facility-based programs are the most promising way to assure consistent nationwide production of high-quality diagnostic radiographs at minimum cost and patient exposure. The aim is to provide health practitioners (and others responsible for the operation of diagnostic x-ray facilities) with recommendations concerning the establishment and implementation of voluntary quality assurance programs.

In soliciting comments in its May 7, 1976 *Federal Register* announcement, BRH specifically asked for information on personal experience of facility-based programs and on their costs and benefits.[10]

Gonad Shielding

A final FDA voluntary recommendation[11] endorsed the concept of appropriate use of specific area gonad shielding during diagnostic x-ray exams. It advised shielding when: (1) gonads lie within the primary x-ray field or within close proximity, (2) clinical objectives will not be compromised, and (3) the patient has a reasonable reproductive potential. To be implemented through educational programs and cooperative activities of professional organizations, the gonad shielding guidance is the first to be published in a new Subpart C of Title 21 of the *Code of Federal Regulations*, "Radiation Protection Recommendations."

Exposure During Pregnancy

As an intermediate step in formulating a voluntary recommendation on medical radiation exposure during pregnancy, the Bureau published "Clinical Methods of Avoiding Medical X-Ray Exposure of the Human Embryo and Fetus: A Technical Overview."[12] It analyzed the benefits and limitations of current recommendations for women of childbearing age and suggested a possible alternative approach to clinical management of potentially pregnant women. Following assessment of comments on the report and if such recommendation is still warranted, a proposed recommendation will be published in the *Federal Register* for public review.

Mammography Recommendations

BRH is working with other health agencies and with professional groups to develop a joint policy statement or guideline on mammography screening. The BRH Medical Radiation Advisory Committee suggested the following to the Bureau for guideline consideration:

— "Women of all ages should receive annual physical examinations of the breast and be taught breast self-examination. For asymptomatic women the first, or baseline, mammographic examination should be performed between the ages of 35 and 40.

— "A second mammographic examination should be performed in three to five years unless indications of increased natural breast cancer risk for an individual warrant more frequent examinations.

— "Subsequent mammographic examination of women who remain asymptomatic should depend upon reevaluation of the patient's personal risk status, the current understanding about the efficacy of mammography, and evaluation of radiation risks.

— "After age 50, annual or other regular interval mammographic examinations should be performed."

Memorandum of Understanding

EPA and HEW negotiated a Memorandum of Understanding concerning guidance to Federal agencies on radiation protection in the healing arts.[13] Some main features of the definition of the agencies' responsibilities are:

— EPA will identify areas of potential radiation exposure reduction, in consultation with other agencies.

— EPA will consult HEW on the need for Federal guidance, and on timing, specificity, and adequacy of existing criteria.

— HEW may develop and promulgate a recommendation and transmit it to EPA for review as proposed Federal guidance.

— The agencies will consult on the appropriate division between broad and specific phases of issuing guidance, when it is appropriate to follow broad EPA proposals with specific implementing guidance by HEW.

— When EPA develops guidance, HEW will provide available input, and EPA will address HEW's comments in the public record along with others'.

— EPA will conduct review of proposed Federal guidance developed by itself or HEW.

— EPA will provide appropriate followup and coordination to assure implementation.

X-Rays in Federal Health Care Facilities

An Interagency Working Group formed by EPA in 1974 issued its final report in October on radiation protection guidance for diagnostic x-rays in Federal health care facilities. Two Group Subcommittees submitted background reports:

— The Subcommittee on Technic of Exposure Prevention developed recommendations on quality assurance, radiographic technic, operator qualifications and exposure guides for selected standard examinations.

— The Subcommittee on Prescription of Exposure to X-Rays emphasized the qualifications of people who order examinations, elimination of unproductive screening programs and appropriate clinical procedures.

— Appropriate technic should be used to maintain exposures as low as reasonably achievable without loss of requisite diagnostic information; Entrance Skin Exposure Guides should be established for this purpose and measures should be undertaken to evaluate and, where practicable, reduce exposures which exceed such established guides.

From the recommendations of the Working Group's final report, EPA's Office of Radiation Programs (EPA/ORP) developed proposed Radiation Protection Guidance for Diagnostic X-Rays in Federal health care facilities.[14] Highlights of the proposal follow:

— Prescription of an x-ray study should be for the purpose of obtaining diagnostic information, be based on clinical evaluation, state the diagnostic objective, and detail relevant medical history.

— Routine or screening examinations with no prior clinical examination should not be performed, except for identifiable groups on the basis of careful consideration of diagnostic yield, radiation risk, and economic and social factors.

— Prescription of x-ray examinations of women who could be or are pregnant should assure that medical consideration has been given to possible fetal exposure, and appropriate protective measures should be applied.

— The number, sequence, and types of standard views for an examination should be clinically oriented and kept to a minimum.

— X-Ray equipment used in Federal programs should meet the Federal performance standards sooner than required where practicable, or, in the interim, Part F of the "Suggested State Regulations."

— X-Ray facilities should have quality assurance programs designed to produce radiographs that satisfy diagnostic requirements with minimal patient exposure.

— X-Ray equipment should be operated by individuals with demonstrated proficiency in producing diagnostic quality radiographs with the minimum of exposure required.

— Proper collimation should be used to restrict the x-ray beam as much as practicable to the clinical area of interest and within the dimensions of the image receptor; shielding should be used to limit the exposure of the fetus and gonads even further.

Education and Quality Assurance

Quality Assurance Catalog

BRH began collecting information on materials and resources suitable for its forthcoming *Diagnostic Radiology Quality Assurance Catalog*. Intended as a source book, the *Catalog* will be directed at those who want to establish or expand programs in their own diagnostic radiology facilities.

BRH Training Program Evaluation

BRH evaluated its training program in 1976, and found that by 1980 about 50,000 users of diagnostic x-ray equipment will have benefited from BRH's voluntary recommendations and training materials.

Radiological Health Sciences Learning Laboratory

The Laboratory continued to educate medical students and others in the major segments of diagnostic radiology — including patient selection for x-ray examinations, conduct of the examination, and interpretation of results, with emphasis on reducing unnecessary patient and operator exposure. Since the Learning Laboratory was first made available in 1973, 44 of the 115 medical and osteopathic schools in the U.S. have adopted it, and an additional 22 requests will be filled by January 1978.

Quality Assurance Seminars

BRH conducted a series of nine quality assurance seminars with personnel from existing facility-based programs. After the proceedings were printed, they were distributed to several hundred requesters.

Radiologic Technologist Training Packages

The series of radiologic technologist training packages on radiation protection developed by BRH was expanded to include packages on the biological effects of x-rays and on the use of gonad shielding in diagnostic radiology. The series, "Radiation Protection During Medical X-Ray Examination,"[15] consists of self-contained training packages to teach radiologic technologists how to avoid unnecessary radiation exposure during diagnostic x-ray examinations. Aimed at motivating technologists to use safer practices, the first addition explains known biological risks associated with x-ray exposure; the second discusses the importance of shielding reproductive organs and shows how to do it.

In addition to BRH's present training functions, the General Accounting Office (GAO) recommended in a 1976 report[16] that the Bureau "work more vigorously with States and nonprofit private organizations to establish a uniform national operator credentialing program" to help insure the competency of x-ray machine operators. Current BRH policy is that credentialing of allied health personnel is an issue to be resolved at the State level. Striking the proper balance between the very valid manpower considerations on the part of HEW and the suggestion of the GAO for improved program effectiveness will require extensive evaluation and planning.

Radiographic Film Processing Conference

BRH contracted with the American College of Radiology (ACR) to coordinate a conference on radiographic film processing. ACR will convene a group of nationally recognized experts to review the significance and extent of less than optimal processing, which may result in films of poor diagnostic quality, and to discuss the importance of quality assurance in this area.

Prior to the conference, the ACR will perform a literature search to develop bibliographies on the relationship between film processing, image quality and patient exposure, and on the establishment and maintenance of optimal processing procedures. This information will be used to prepare a handout that describes the state of the art, defines the major problems to be addressed at the conference, and lists specific questions that must be answered. The proceedings will be prepared by the ACR for publication as a Bureau report.

Self Assessment for Technologists

A BRH contract awarded to the American Society of Radiologic Technologists proceeded toward full implementation of a self assessment program for 6,000 technologists per year. After helping individuals determine their areas of weakness in professional skills, the learning system directs them to appropriate educational materials.

Dental Exposure Normalization Technique (DENT)

During 1976, full scale DENT programs were underway in 16 States, municipalities and Federal agencies, reaching 34,000 dental x-ray machines in addition to the 35,000 covered by pilot programs in nine other States. DENT is a program developed by BRH to encourage dentists to standardize dental x-ray machine exposures within established ranges that produce high quality x-ray films with acceptable patient exposures. It is primarily an educational effort, rather than the usual survey to check for compliance with State regulations.

Breast Exposure: National Trends (BENT)

BRH is collaborating with the National Cancer Institute to make a mammography quality assurance program known as BENT available to all States during the next two years. A pilot test has already been completed in the District of Columbia, and four States are testing it now. Thermoluminescent dosimeter (TLD) cards are mailed to all participating facilities, who expose them according to their usual practices and provide information on their image receptor and processing. After assessing the data, BRH identifies facilities that appear to be using excessive exposure. They are then visited by trained personnel from the State health department who survey the facility and suggest improvements in technique.

Film on Safe Use of Analytical X-Rays

A 16-mm color film, "The Double-Edged Sword," was produced by a contractor in a joint project between BRH and the National Bureau of Standards. The theme of the film is that x-rays have many useful applications in analytical laboratories, but the serious injuries that result from accidental exposure to their intense beams make them a "double-edged sword." The presentation aims to convey a sense of urgency and to motivate the viewer to make better use of detailed guidelines.

Surveillance Manual

The Task Force on Quality Assurance — a group of Federal and State representatives recently established by the Conference of Radiation Control Program Directors — is planning to develop a quality assurance surveillance manual for publication by the Conference. As a first step toward developing the manual, BRH representatives will review existing Federal quality assurance programs.

The specific charges of the Task Force are to: (1) define the areas of diagnostic x-ray use in which quality assurance is needed and describe the basic factors in all quality assurance programs, (2) examine current diagnostic x-ray programs in Federal agencies and serve as the focal point for State input into these programs, and (3) report to the Conference on quality assurance programs and techniques that can be used by State radiation control programs.

Consumer Information Programs

BRH prepared messages and other material advising women of specific steps to reduce the risk of x-ray exposure to unborn children. The director's presentations to consumer groups included one on risks versus benefits in diagnostic radiology at the University of Georgia, and one on protection at a meeting of 150 organized by the Region III Consumer Affairs Officer.

Compliance

Automated System for Survey Instruments

BRH is installing an automated system for calibrating and maintaining records of x-ray survey instruments, to replace a manual process which had become inadequate. The facility is being automated gradually, with extensive tests made at each stage to verify the performance of the system. Eventually, the computer will handle most of the routine "button pushing" while the operator monitors the quality of the work. The possibility of multiple, simultaneous calibrations has been designed into the system along with the capability for automatically positioning sequential instruments in the x-ray beam. These functions will greatly reduce the calibration time and enable large numbers of instruments to be monitored easily and quickly.

State Contracts for Diagnostic X-Ray Equipment

The radiation control agencies of ten States and the Commonwealth of Puerto Rico were added to the seven State agencies already participating in the Bureau's x-ray compliance testing program. New contracts with Arkansas, California, Hawaii, Kentucky, Massachusetts, Mississippi, North Dakota, Puerto Rico, South Carolina, Texas, and Wisconsin call for State agencies to inspect and gather test data on 2,000 certified diagnostic x-ray systems to aid the Bureau in determining compliance with the Federal x-ray equipment performance standard.

These contracts represent an expansion of the Bureau's efforts to provide State programs with funds in order to obtain additional technical assistance in the enforcement of the diagnostic x-ray standard. Colorado, Florida, Minnesota, New Jersey, Oklahoma, Pennsylvania, and the District of Columbia currently are carrying out diagnostic x-ray system inspection and testing programs under previous Bureau contracts.

Under the terms of the contracts, each agency will survey a specified number of diagnostic x-ray systems that contain newly certified components according to test procedures designated by the Bureau. Test data will be submitted to the Bureau and will serve as the basis for compliance action when warranted.

Corrective Action Programs

Thirty-three compliance action cases were initiated with manufacturers of diagnostic x-ray equipment. Eleven instances of noncompliance were reported by manufacturers; ten were noted during reviews of initial reports; seven were discovered during field testing; two were found during a plant visit; and three were discovered during laboratory testing. Eight major components of x-ray systems and six complete x-ray systems have been laboratory tested in accordance with the Federal Performance Standard for Diagnostic X-Ray Systems and Their Major Components. Three quality control and testing programs were disapproved pending further information or a change in the program. Two of these disapprovals were rescinded after receipt and review of additional submissions.

Sample programs for medical equipment included:

— Picker Corporation: to repair 388 automatic brightness stabilizers used in fluoroscopic x-ray systems by changing a wire from one terminal to another to prevent the x-ray tube from producing x-rays when the primary protective barrier is not in a position to intercept the entire useful beam.

— General Electric Medical Systems: to modify 358 single-phase x-ray generators used in medical diagnostic radiographic equipment, by instructing field service personnel to visit each user facility and apply a label that pre-indicates tube current for spot film exposures.

— Pedicraft, Inc.: to provide users of 68 cephalometric devices with the proper labels, user information, assembler information, and an adjustable cephalometric cone. Each user will make the corrections and fill out an assembler's report, which will be submitted to the manufacturer as proof that the modifications have been made. Items of noncompliance included lack of a quality control program; no records of radiation safety test procedures or the distribution of units introduced into commerce; inadequate labeling; no provision of specified information to assemblers; no provision of a maintenance schedule to users; and no means to limit the field of the x-ray beam within the dimensions of the image receptor, or to align the center of the x-ray field with the center of the image receptor to within two percent of the source-to-image distance.

Sample programs for dental equipment follow:

— General Electric Company: to notify owners of 1065 GH 1000 (conventional) and 909 GE Panelipse (panoramic) units of noncomplying features and to repair them. On both models, the actual variation in maximum tube voltage exceeds the accuracy limits specified by the manufacturer. The Panelipse also has other deficiencies.

— Ritter Company: to send users and dealers of 1,577 Ritter x-ray systems used for intraoral dental radiography (models Meteor II R1, R2, and R4, and Explorer II P3) a packet containing: labels for the collimator, tube housing assembly, and timer selector assembly; a statement of maximum line current for the lowest rated line voltage; and a recommendation that timer settings of one and two pulses not be used.

— Belmont Equipment Corporation: to instruct dealers to obtain the addresses of purchasers of 551 dental x-ray machines, modify the units so positive means are provided to assure that at least minimum filtration is in the useful beam, and supply purchasers with the required labels and user information.

— Weber Dental Manufacturing Company: to provide each user of 90 dental x-ray machines with an addendum to the user manual containing a consistent statement on rated line voltage, a statement of maximum line current for lowest rated line voltage, a statement of measurement bases for technique factors, and consistent assemblers' instructions for certain calibration.

Studies

Nationwide Evaluation of X-Ray Trends (NEXT)

Fourth year data was collected in NEXT, a joint Federal/State program supported by BRH. NEXT measures the exposure received from standard x-ray examinations at different facilities, providing the States with information to set program priorities and evaluate protection progress, and the FDA with a tool for monitoring x-ray trends. In all, 43 State and local radiation control programs and seven Federal agencies were participating in NEXT at the end of 1976. Analysis of the data collected in 15,000 surveys of U.S. medical and dental radiographic installations indicates:

— in many cases high patient exposure correlates with above average normalized machine output; and

— there is a wide variation in radiologic practices and patient exposure, suggesting a need for quality assurance efforts by health physicists.

In addition to the regular program, a one year pilot study began in 13 States to determine the usefulness of optional survey procedures gathering information on films, screens, and processing techniques.

Bone Marrow Dose to Adults

A BRH report[17] estimated that the per capita mean active bone marrow dose to U.S. adults from diagnostic radiology procedures in 1970 was 103 millirads, compared to 83 in 1964. Providing explanations of its dose determinations and the relationship between age and per capita dose, the report compares results of Public Health Service studies in 1970 and 1964 to similar studies performed in other countries.

Organ Doses in Diagnostic Radiology

To help evaluate the effectiveness of efforts to reduce organ doses in x-ray examination, FDA developed a system for estimating organ doses as a function of the physical parameters used during diagnostic procedures. The estimates are derived from a Monte Carlo computer technique that statistically simulates and records the deposition of x-ray photons in an anthropomorphic phantom.

Mammographic Screening

BRH proceeded with its evaluation of risks and benefits of routine mammographic screening of asymptomatic women for breast cancer. New data is being incorporated to reflect recent radiological practice and technological progress in mammography.

Work began on a BRH contract study to determine the combinations of x-ray spectra and image receptor characteristics that will enable radiologists to detect breast microcalcifications — small calcium deposits that may be indications of breast cancer — with minimum radiation dose to the patient. The project is designed to augment the findings of a previous study of the optimum x-ray spectra for visualizing tumor bodies by mammography.

X-Ray Operator Job Performance

BRH accepted the final report of a pilot study titled "An Analysis of Factors Which Affect the Performance of Medical X-Ray Equipment Operators." In addition to collecting information on operators, their workplaces and practices, the study made cross comparisons to determine which background and environmental factors tended to have the strongest influence on certain practices.

Skull X-Ray Selection Criteria

Two Seattle, Washington, hospitals began a study to determine whether physician use of specified selection criteria for ordering skull x-rays in trauma cases reduces the number of unnecessary exposures. One hospital uses such criteria while the other does not.

• Computered Tomography Systems

Guidance

BRH is considering amending radiation safety performance standards for diagnostic x-ray equipment to recognize special characteristics of tomographic systems used for pantomography or those which use reconstruction techniques to produce an image. Because the present standards were developed before tomographic systems were envisioned, they include requirements which may be inappropriate for the new equipment. Some of the changes being considered are:

— a clearer definition of x-ray field limitation and alignment requirements, and

— permissible means for the newer systems to resume and complete interrupted exposures, rather than automatically resetting the timer to zero or its initial setting as in conventional systems.

BRH met and consulted with industry representatives on these and other possible amendments, and invited public comment.[18]

Compliance

BRH notified CT manufacturers that, while the Bureau was considering modification of its existing standards to provide specifically for such units, they should heed present regulations or apply for an authorized deviation from them. In November, corrective plans were approved for 267 EMI Medical units which failed to comply with the diagnostic x-ray equipment standard. Purchasers will be notified of the noncompliance by certified mail, and the source collimation systems on each unit will be replaced with redesigned collimators. EMI service personnel will perform the modifications at user facilities during routine preventive maintenance visits.

Corrections were required on 550 General Electric diagnostic x-ray machines. They will consist of indicating the tomographic exposure time on the control of the Telegem-90 table system, specifying the tomographic exposure time accuracy in the operating manual for the Telegem-90 system, and disabling the "record test" function on all machines that use the Fluoricon-300 IV image intensifier. Each customer will sign a certification form, to be returned to GE, verifying that corrections were performed.

Studies

Panoramic Dental Units

While stray radiation was found to be uniformly low, three of the most commonly used panoramic dental units resulted in substantially different internal exposures to patients, according to a BRH supported study.[19]

• Nuclear Medicine

Education and Quality Assurance

Manual on Quality Assurance for Scintillation Cameras

BRH published a new "Workshop Manual for Quality Control of Scintillation Cameras in Nuclear Medicine."[20] It gives special consideration to instrument components which influence image quality, materials and methods for ascertaining changes in performance, and common malfunctions. It is designed to encourage users of scintillation cameras to adopt quality control procedures to maintain adequate instrument performance levels.

Course on Instructional Techniques for Radiation Protection

The Bureau offered "Instructional Techniques: Radiation Protection in Nuclear Medicine,"[21] its first course on the types of training aids, devices and techniques available for teaching radiation protection to nuclear medicine technologists. Specific topics addressed are biological effects, principles of radiation protection, communicating radiation protection to the patient, and performance evaluation.

Radiopharmaceutical Dosimetry Symposium

BRH cosponsored a Radiopharmaceutical Dosimetry Symposium where latest concepts of internal dosimetry were discussed. As a sequel to a 1969 symposium whose proceedings have been a standard reference, a transcript will be published to make findings available to nuclear medicine practitioners and clinical investigators.

Quality Assurance Workshops in Nuclear Medicine

To promote training of nuclear medicine technologists in radiation safety practices, BRH awarded a contract to develop two new quality assurance workshops:

— *Quality Assurance of Handling and Assay of Radioactive Materials* will cover radiopharmaceutical quality control testing, generators of radionuclides, xenon handling systems and their operation, and basic radiation safety policies and procedures recommended for hospital and laboratory use, with emphasis on Federal and State requirements.

— *Quality Assurance of Rectilinear Scanners* will provide instruction on scanner evaluation and operation, characteristics and quality control of films, daily quality assurance practices, and choice of phantoms.

Compliance

Hospital Patients Overexposed

In April 1976, the NRC was informed by the Riverside Methodist Hospital in Columbus, Ohio, that about 400 of their patients had received radiation treatment doses that ranged from ten percent to 40 percent in excess of the prescribed amounts, with an average overdose of about 19 percent. The persons affected were primarily patients taking radiation treatment for cancer, although for some radiation was prescribed as preventive therapy following other medical procedures, and, for some others, as a moderator of the intensity of the condition.

A radiologist's concern about the response of patients to the treatment led to a calibration check on the teletherapy unit in January 1976, when it was revealed that the actual doses exceeded those prescribed. The unit was correctly calibrated at once, and treatment schedules of patients still taking radiation therapy were adjusted, wherever possible, to avoid exceeding the overall total dose intended for each. All patients and physicians involved were informed by the hospital of the situation. With regard to patients who had died since the time of treatment, reviews were undertaken. The coroner for Franklin County, Ohio, stated that, of 30 cases reviewed, autopsies showed that radiation exposure was a contributor to death in two instances. The cause of the excessive doses to the patients was human error.

While the NRC licenses the medical use of nuclear materials, the amount of radiation prescribed in the diagnosis and treatment of a patient is exempt from its regulatory control. Under notification, the NRC instituted an investigation and engaged a medical consultant to review the coroner's findings and advise on medical aspects of the incident. In July 1976, the NRC issued an order modifying the hospital's licenses specifically to require periodic calibration of the teletherapy unit by a qualified expert, in accord with accepted professional procedures. The order also required that management control systems be improved to ensure that public health and safety are protected.

In August 1976, NRC sent a bulletin to all licensees using teletherapy units, directing them to perform comparison tests between their units' actual measured output and the calculated output and, if variances between the two were found, to perform a full calibration of the instrument. NRC also initiated a program to verify independently that the difference between measured and calculated output in the licensees' units was acceptably small. NRC is studying ways to prevent recurrence of this kind of event with the teletherapy unit involved or the approximately 500 other units licensed by NRC through regulation. Besides these, there are about 600 teletherapy units operated under licenses administered by 25 States in the NRC "Agreement States" program. NRC has urged the State authorities to strengthen their licensing programs along the same lines, and State personnel have participated in a three-day training course in teletherapy unit calibration under NRC sponsorship.

Studies

Short Lived Radionuclides

The Bureau's Task Force on Short Lived Radionuclides for Medical Use reviewed preliminary reports on: (1) decreasing the administered dose of iodine-131 for diagnostic purposes, (2) reducing the number of iodine-131 studies performed, (3) the risks versus benefits of shifting from iodine-131 to iodine-123, including the economic and environmental impact, and (4) the application of short-lived radionuclides in other nuclear medicine procedures.

In addition to these areas, the Task Force recommended that the reports cover the role of technetium-99m in thyroid imaging, and define the research efforts required to substantiate the need for short-lived radionuclides. The group also drafted a report in June suggesting measures to reduce patient dose.

Nuclear Medicine Information Systems

The Task Force on the Public Health Impact of Nuclear Medicine Practice started reviewing existing data sources and evaluating their potential contribution to developing reliable estimates on current practices and trends in nuclear medicine. It is a group of Federal and State representatives established by the Conference of Radiation Control Program Directors. Ultimately, the Task Force hopes to develop a data system usable for estimating specific parameters related to the public health impact of the clinical practice of nuclear medicine. The Task Force includes members from both EPA and BRH.

Childhood Exposure to Iodine-131

BRH and NRC began collaborating on a followup study of people who received diagnostic doses of iodine-131 during childhood. The primary aim is to determine if the clinical procedures used for the investigation of endocrine disorders during childhood are associated with adverse health effects later in life — particularly benign and malignant thyroid tumors. If they are associated, the nature of the relationship between them will be investigated. Ultimately, the five-year effort will involve identification and followup of 19,500 persons — 6,500 subjects exposed to iodine-131 between 1948 and 1967; 6,500 sibling controls; and 6,500 clinical controls.

Scintillation Camera Image Quality

To assess the effectiveness of quality assurance for scintillation camera images, a grant was awarded to investigate parameters affecting quality, and to provide quantitative data on the clinical problems associated with the use of cameras with graded degrees of maladjustment.

• Cabinet X-Ray Systems

Guidance

"BRH Routine Compliance Testing for Cabinet X-Ray Systems"[22] was prepared by the Division of Compliance to explain the test procedures to be used to screen systems for evidence of noncompliance with the Federal performance standard. It describes the general procedures for testing items common to all cabinet x-ray systems, as well as a number of specific procedures applicable to particular cabinet x-ray models, such as systems used to inspect carry-on baggage in airports.

Compliance

Automatic data processing systems were established at BRH to maintain a current list of the locations of cabinet x-ray units, and to analyze the results of field tests. (Most tests are made to comply with a Federal Aviation Administration requirement that airport x-ray units be surveyed semiannually.) Overall, 52 systems were involved in corrective actions on four noncompliances/defects. Two quality assurance and testing program disapprovals were continued from 1975; eight new programs were disapproved, although five of these were rescinded after additional information was submitted.

• Ultrasound

Guidance

BRH issued a proposed safety performance standard for ultrasonic therapy and surgery equipment in the June 14 *Federal Register* (41 F.R. 23973). While two voluntary industry standards are now in effect, many units produced do not meet them. The new mandatory standard would require that equipment be capable of delivering a prescribed amount of ultrasonic energy to the patient, and that sufficient information on beam characteristics be supplied to allow medical personnel to make informed judgments. According to the proposal, the standard would apply to all ultrasonic therapy and surgery products except those designed for use in dentistry or for surgical removal of cataracts. It would not cover diagnostic equipment.

Studies

BRH convened a panel of scientists and technical experts to review the Bureau's research efforts on ultrasound bioeffects and measurements, and to exchange information on the latest developments. As well as recommending additional areas of study, the panel discussed epidemiological studies, somatic effects, interrelationships of ultrasonic delivery, regimes, embryological effects, genetic effects, sterility in the male, and safety considerations.

BRH research in the area includes:

— a contract to develop a portable instrument for measuring and visually displaying the output characteristics of diagnostic and therapeutic ultrasound devices.

— a hospital survey to determine the frequency of use and selected parameters of use of (1) phototherapy for neonatal jaundice and (2) ultrasound for the diagnosis of obstetric conditions. The data were collected in 1976 and analysis is underway.

— a feasibility study to determine whether a full scale study of possible delayed effects of ultrasound on the fetus can be made using obstetrical examination records from 1967–69 as the starting point.

In addition, the Bureau of Radiological Health and the American Institute of Ultrasound in Medicine (AIUM) cooperated in a survey to evaluate the performance and use of diagnostic ultrasound equipment in approximately 50 medical facilities. BRH's aim was to obtain information bearing on the need for a possible Federal radiation safety performance standard. The AIUM is particularly interested in assessing the effectiveness of a special 100-millimeter test object it has designed for checking the imaging ability of the equipment.

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4. *BEIR Report.*

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14. "Diagnostic X-Rays, Radiation Protection Guidance; Invitation for Comment." EPA: 42 F.R. 4884 (January 26, 1977).

15. "Radiation Protection During Medical X-Ray Examinations – Part 4 and Part 5." BRH: FDA 76–8048–9 (1976).

16. "Radiation Exposure from Diagnostic X-Rays Could be Reduced." General Accounting Office: HRD-77-22 (November 24, 1976).

17. "A System for Estimation of Mean Active Bone Marrow Dose." BRH: FDA 76–8015 (1975). GPO 017–015–00092–3, $1.15.

18. "Diagnostic X-Ray Equipment Performance Standard: Tomographic Systems, Advance Notice of Proposed Rulemaking." BRH: 41 F.R. 43180 (September 30, 1975).

19. Comparison of Radiation Exposures from Panoramic Dental X-Ray Units. BRH: FDA 77–8009 (1977).

20. "Workshop Manual for Quality Control of Scintillation Cameras in Nuclear Medicine." HEW/PHS/FDA/BRH: HEW Publication (FDA) 76-8039 (May 1976).

21. "Instructional Techniques: Radiation Protection in Nuclear Medicine." 10 *BRH Bulletin* No. 1 (January 12, 1976).

22. "BRH Routine Compliance Testing for Cabinet X-Ray Systems." BRH: FDA 76–8028 (1976).

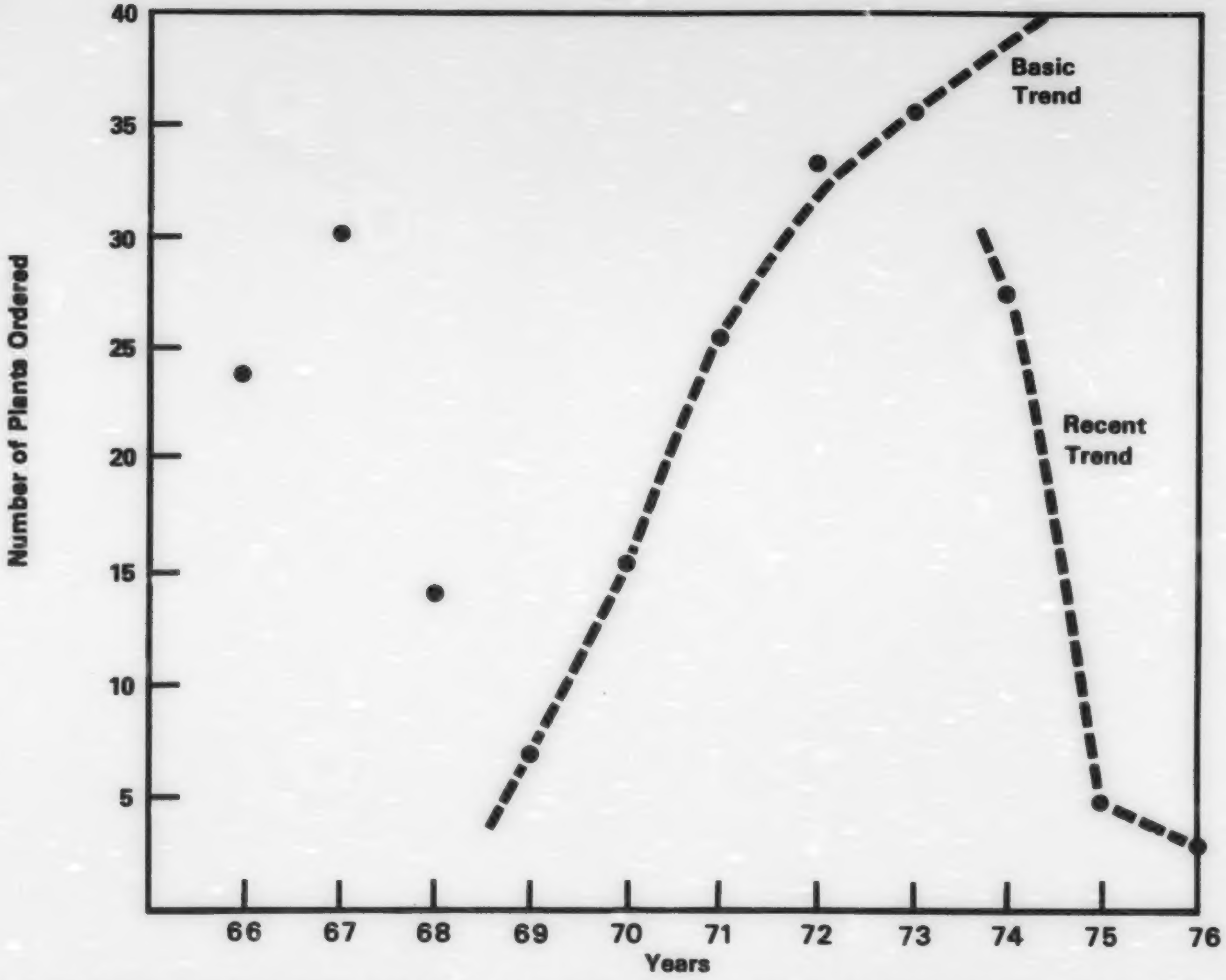
Below are publication numbers for relevant items cited in Appendix B. Since most BRH Technical Reports will be helpful, they are not listed separately below; see the full information in the Appendix.

EPA Technical Reports: 520/4–76–012, 520/4–76–019

EPA Authored Reports: See Martin

ERDA Publications: ERDA-76/135

Figure 4.1



U.S. REACTOR ORDERS EACH YEAR. WHILE THE TREND LINE WOULD INDICATE ABOUT THREE DOZEN ORDERS/YEAR MIGHT NOW BE EXPECTED, 1976 ORDERS WERE DOWN TO 3.

NUCLEAR POWER

1. Introduction and Summary

Nuclear power is by far the most controversial source of man-made radiation. While it accounts for only a small percent of the average American's exposure, nearly all scientists agree that any dose of radiation from any source involves some risk. The long term environmental burden must be considered as well as the risks to individuals, since many radioactive substances have half-lives of hundreds or thousands of years.

The basic controversy is how much risk people are willing to assume — for themselves, the world environment, and future populations -- to gain the benefits of nuclear power. There is widespread and violent disagreement about nearly all the factors in the risk/benefit equation: what the effects of low level radiation are, how much nuclear power will cost relative to the alternatives in ten years, what the danger of an accident is, if and how wastes can be contained for milennia, and so on almost *ad infinitum*.

Emissions from nuclear power plants can be reduced to virtually any level with appropriate controls — but the costs of each increment of reduction must be weighed against preventing risks whose significance is still in debate. The above considerations alone would make policy decisions complex and difficult; a further complication is the threat of nuclear proliferation, particularly when combined with the possibility of terrorist diversion of nuclear materials.

This chapter deals only with the radiation protection aspect of these issues, including limited material on preventing accidents whose aftermath would require protection activities.

Industry Status

As background to that discussion, the status of the nuclear power industry in 1976 is described partially by Figure 4.1, showing that, for the second straight year, orders for new reactors were dramatically below the expected numbers. Only three new orders were made in 1976, while about three dozen a year might be expected according to the trend line.

Another way to look at the industry status is that there were 237 nuclear power units either in operation, being built or planned, which represent a total capacity of 237,000 net megawatts electric (MWe). Of these 237 units (as of September 30, 1976), 202 had entered the NRC licensing process, as follows:

— 62 licensed to operate, with a total capacity of 45,000 MWe;

— 72 with construction permits, representing 76,000 MWe capacity;

— 68 under review for construction permits, representing 75,000 MWe capacity.

Initial construction work was proceeding on 21 of those under limited work authorizations; of the remaining 35 units, 16 had been ordered and 19 publicly announced.[1]

Presidential Statement

The most important nuclear policy event of 1976 was President Ford's October 28 statement[2] announcing decisions that: (1) the reprocessing and recycling of plutonium should not proceed unless there is sound reason to conclude that the world community can overcome effectively the associated risks of proliferation of nuclear explosives capability, (2) the avoidance of proliferation must take precedence over economic interests, and (3) the U.S. and other nations should increase their use of nuclear power for peaceful purposes even if reprocessing and recycle of plutonium are not found acceptable.

The President also announced specific guidelines for action concerning the framework of controls for U.S. nuclear export activities. These guidelines included applying new criteria in judging whether to enter into new or expanded agreements for peaceful nuclear cooperation, and directing the Secretary of State to:

— enter into negotiations to conform existing agreements between the United States and cooperating nations with established international guidelines and the new U.S criteria;

— intensify discussions with nuclear suppliers aimed at expanding common guidelines for cooperative agreements; and

— work closely with the NRC to ensure appropriate emphasis on nonproliferation concerns in the nuclear export licensing process.

All nations were asked to join with the United States in exercising maximum restraint in the transfer of reprocessing and enrichment technology and facilities, by avoiding these sensitive exports or commitments for at least three years. The statement also called for the development of means to establish international restraints over the accumulation of plutonium.

In addition, the President directed that ERDA:

— identify research and development efforts needed to define a reprocessing and recycle evaluation program, consistent with the U.S. goal of building an effective system of international controls to prevent proliferation of nuclear explosives capability;

— investigate the feasibility of recovering energy value from used nuclear fuel without separating plutonium;

— speed up the program to demonstrate all components of waste management technology by 1978; and

— demonstrate the operation of a complete repository for nuclear wastes by 1985. (The waste repository plans will be submitted to NRC for licensing.)

NRC is in the process of deciding whether and to what extent it will license the use of recycle plutonium in mixed oxide fuel. The decision will be based partly on consideration of ERDA's work as mandated above, along with NRC's Generic Final Environmental Statement on health and environmental issues and a forthcoming Statement on safeguards. Another source of input will be the public hearings held on both Statements and related questions.

Summary

Congress explored many issues in the nuclear power field in 1976, although few bills actually became law. Among the significant hearings discussed in full below are:

— *Reactor Safety Study review*: The Rasmussen Study's methodology and conclusions were reviewed by executive agencies and independent witnesses.

— *Exports and proliferation*: Despite much activity, the only provision actually passed in this area was an amendment to the military aid bill prohibiting economic assistance to countries who bought or transferred reprocessing equipment or materials without establishing international safeguards for them.

— *Breeder reactor restrictions*: Several attempts to restrict development of the breeder reactor failed in both Houses — including one which would have made utilities responsible for a certain percentage of cost overruns above two billion dollars.

— *Radioactive wastes*: Hearings ranged from low level waste disposal, general waste management, and radiological contamination of the ocean to the process ERDA used in conducting negotiations on a possible storage site.

— *Insurance and indemnity*: Congress passed a new version of the Price-Anderson Act, which provides a system to pay public liability claims in case of a nuclear incident involving personal injury and property damage.

— *Low level radiation*: A Congressional Seminar was held to air varying scientific opinion about the biological effects of low level radiation.

The judiciary addressed a number of cases related to nuclear power in 1976. One of the most important established that EPA has no regulatory jurisdiction over radioactive waste materials discharged into water from NRC licensed facilities. New York is trying to ban air transportation of special nuclear materials; an appeal was pending at the end of 1976. The most dramatic decisions were two from the U.S. Court of Appeals, which resulted in a temporary suspension of licensing by NRC. The Court held that the rule governing NRC's consideration of the environmental impact of reprocessing and waste disposal in its reactor licensing process must be more fully explained and documented.

Other cases touched on such issues as the export program and the National Environmental Policy Act, radioiodine reduction, mixed oxide fuels, and the constitutionality of the Price-Anderson Act.

The section on executive agencies includes discussion of comprehensive activities which cover the entire fuel cycle, as well as activities related to specific issues. Below are brief descriptions of a few of the most significant.

• Comprehensive

EPA's Office of Radiation Programs (EPA/ORP) issued new radiation protection standards for planned releases from nuclear power facilities in the entire uranium fuel cycle, from mills to fuel reprocessing establishments.

NRC followed its 1975 guidelines for levels of radioactive material in reactor effluents by issuing many regulatory guides and technical reports for public comment.

EPA/ORP reviewed the Rasmussen *Reactor Safety Study*, concluding, among other things, that health effects after an accident were not addressed fully, and that the assumptions for evacuation as a protective action were deficient.

NRC released the health, safety, and environmental part of its Final Generic Environmental Statement on the use of recycle plutonium in mixed oxide fuel in light-water-cooled reactors. EPA/ORP's review of the Statement contended that the technology necessary to close the fuel cycle has not been finally established, and, until it is, the economic basis for plutonium recycle would be speculative.

Along with three other agencies, ERDA issued a Final Environmental Statement on U.S. Nuclear Export Activities, to assess the Atoms for Peace program (designed to spread nuclear power to other countries) from its inception in 1954 through the year 2000. EPA and ERDA agreed that a later, separate assessment of the impacts of returning exported U.S. fuel would be made, if reprocessing becomes part of U.S. policy.

• Waste

NRC temporarily suspended licensing as a result of two U.S. Court of Appeals decisions. They relate to the manner and degree to which NRC considers the environmental impact of reprocessing and waste disposal in its reactor licensing process.

NRC published its Supplement 1 to WASH-1248, "Environmental Survey of the Reprocessing and Waste Management Portions of the Light-Water Reactor Fuel Cycle." EPA/ORP's view is that the report does not meet the stated purpose of clarifying and elaborating on the environmental impacts associated with the defined portions of the cycle.

• Spent Fuel

NRC prepared a Draft Generic Environmental Impact Statement on its evaluation of handling, shipping and storing spent light water reactor fuel during the next ten years. It will be published in 1977.

• Transportation

NRC completed a Draft Generic Environmental Impact Statement to assess transportation of radioactive materials, including the costs and benefits of alternative modes. EPA/ORP rated the Draft "environmentally unsatisfactory" because it considered doses to individual passengers excessive.

• Accident Prevention

NRC published "Recommendations Related to Browns Ferry Fire," concluding that most existing facilities needed improvements in fire prevention and control. Detailed fire protection guidelines for nuclear power plants followed in June.

Extensive water reactor and advanced reactor safety research was conducted, including four tests at the Loss of Fluid Test Facility (LOFT).

NRC evaluated the potential problems in a General Electric containment design, and concluded that the systems would perform their function without interfering with other emergency systems. Licensees employing the GE system were required to change operations to increase the safety margin.

• Emergency Response Planning

EPA/ORP conducted an extensive program, including preparation of a "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents," and participation in interagency and international activities.

The General Accounting Office released a report titled "Stronger Federal Assistance to States Needed for Radiation Emergency Response Planning."

2. Major Congressional and Judicial Activities

• Congressional

In addition to its standard yearly authorization and appropriation hearings for each agency, Congress examined many different angles of the nuclear power issue, from perspectives ranging from the most enthusiastic to the most skeptical. Some of the hearings related to radiation protection are discussed below; while there are a great many — even more than those related here — very few bills reached enactment.

Reactor Safety Study Review

The House Interior Subcommittee on Energy and the Environment examined on June 11, 1976, the conclusions and methodology of the *Reactor Safety Study* conducted by Dr. Norman Rasmussen's group.[3] In addition to touching on the implications of the Browns Ferry fire, witnesses considered the usefulness of the *Study* in determining limitations on liability under the Price-Anderson Act (see below under Insurance and Indemnity). Among those testifying were Dr. Rasmussen, NRC, ERDA, independent scientists, and an industry representative.*

Exports and Proliferation

An amendment to the military aid bill was the only important piece of legislation actually enacted to slow nuclear proliferation in 1976. The House/Senate Conference Committee adopted a Senate provision prohibiting economic assistance to countries who bought or transferred reprocessing equipment or materials without establishing international safeguards for them. While the Committee agreed, it added the qualification that the President could make exceptions if he certified that the country would not make nuclear weapons itself or help others to, and if a prohibition would have a serious adverse effect on U.S. interests. (Congress could reverse the President by a joint resolution within 30 days of his submitting such certification.)

Although no other legislation was enacted, Congress spent much time and energy investigating and debating the export and proliferation issue. Two bills were the focus of attention:

> *The Export Administration Act* would have provided tighter safeguards and improved controls on proliferation. A House amendment would have, among other things, (1) given the U.S. veto power over fuel used in U.S. supplied reactors and (2) requested other governments covered by International Atomic Energy Agency safeguards to report on levels of plutonium, U-233, and highly enriched uranium. Although both Houses passed a bill, no Conference Committee was appointed to resolve their differences.
>
> *The Export Reorganization Act* would have set down procedures to be followed in licensing exports. All authority would have been concentrated in the NRC, which would have had to consider the other country's safeguards in making its decision. Also, the Arms Control and Disarmament Agency would have been required to submit a "Nuclear Proliferation Assessment Statement." This bill was replaced with a drastically different substitute after agencies protested; it in turn was succeeded by a compromise bill which was passed out of Committee but not the House. Key elements of the second version were: requiring assurances that certain international safeguards be applied to all U.S. exports; prohibiting peaceful explosions; banning reprocessing, without U.S. approval, of any U.S. fuel or fuel from U.S. reactors; and requiring adequate physical security.

Extensive hearings were held in a number of Committees considering these two measures, and it seems likely that the next Congress will pass a bill based in part on the voluminous legislative history already compiled.

The Senate did adopt a less sweeping measure, which died in the last hours of the 94th Congress, to require Congressional review of new export license requests from countries who have not ratified the nuclear non-proliferation treaty. It would have applied specifically to Brazil, India, Israel, Portugal, Spain and South Africa.

Breeder Reactor Restrictions

Several attempts to restrict development of the breeder reactor failed in both Houses in 1976:

— an amendment to make utilities building the Clinch River breeder reactor responsible for a certain percentage of cost overruns above two billion dollars. The project was originally estimated at $699 million in 1972, and was raised to $1.95 billion by 1976.

— an amendment to force Federal officials to make a firm safety determination on the Clinch River plant before building it. Instead, a proposal asking for "reasonable assurance" was adopted in the House.

Radioactive Wastes

Congress heard testimony on many aspects of radioactive waste disposal in 1976, ranging from general policy questions about how much ocean and land dumping should be permitted and under what conditions, to specific consideration of a particular possible site in Michigan. No laws were enacted as the result of the hearings.

In February the House Government Operations Committee's Subcommittee on Conservation, Energy and Natural Resources began hearings on low level radioactive waste disposal.[4] In addition to EPA/ORP's testimony, the Subcommittee heard U.S. Geological Survey recommendations for improved site selection criteria and for more research. Other witnesses included the industry, State radiological health officials, and the NRC, which described its responsibilities and programs. As a result of the hearings, the Subcommittee published H. Rpt. 94-1320 on June 30, titled *Report on Low Level Nuclear Waste Disposal.*[5]

The now defunct Joint Committee on Atomic Energy held hearings May 10-12 on radioactive waste management, in its Subcommittee on ERDA, Environment and Safety.[6] The most important new policy to emerge in the hearings was ERDA's decision to involve the public more extensively in the development of environmental impact statements. Also discussed were the agency's research progress, developing technical options, and new programs. NRC explained its planning and regulatory program activities, and contamination problems at sites already in use. Other witnesses were from EPA/ORP, the National Academy of Sciences, and the U.S. Geological Survey.

To deal with the issue of radiological contamination of the oceans, the Subcommittee on Energy and Environment of the House Interior Committee devoted two days (July 26-7, 1976) to oversight hearings on past and ongoing dumping practices.[7] In particular, the hearings addressed the possibility of contamination of the marine environment. EPA, which issues permits for ocean dumping, detailed the technical program on which the permits are based. Although past policy has been to dilute and disperse radioactive wastes, EPA's current practice requires that any materials contemplated for disposal be contained and isolated from the marine environment. The Subcommittee also heard testimony from the Department of State on international aspects of the problem, from ERDA on research status, and from NRC on the licensing process and its conclusions on possible impacts.

At a September 17, 1976, hearing of the Subcommittee on Conservation, Energy, and Natural Resources (House Government Operations Committee), EPA/ORP presented the results of continuing surveys of deepsea radioactive disposal sites.[8] The Agency stressed that it sees no health hazard to people or the marine environment from dumping practices in the past. Another issue discussed was EPA/ORP's role in assisting the NRC in implementing a court decision

requiring them to study further the effects of waste disposal on the environment. In addition to providing generally applicable environmental standards for disposal of high level wastes, EPA/ORP said it was ready to assist NRC if the Commission requested help.

In March 1977, the Subcommittee on Energy and Environment (House Interior Committee) published a report titled *Proposed Nuclear Waste Storage in Michigan*, based on hearings held on July 6, 1976.[9] The subject was the lack of participation of citizens and their representatives in negotiations on a possible storage site, conducted by ERDA, Union Carbide, and the Michigan Department of Natural Resources. Testimony was heard from ERDA, EPA, public interest groups, and State and local officials, focussing largely on the division of responsibilities among them and on the ERDA proposal to conduct test drilling for geological data relevant to site determination.

Insurance and Indemnity

The Price-Anderson Act originally provided a system of private insurance and government indemnity totaling $560 million to pay public liability claims in the unlikely event of a nuclear incident involving personal injury and property damage. The Joint Committee on Atomic Energy held hearings on March 3 to consider whether the financial risk to the insured utilities should be increased.[10]

On December 31, 1975, the Price-Anderson Act was modified and extended until August 1, 1987, with the passage of Public Law 94-197. Among other things, this legislation provides for the phasing out of government indemnity by 1985. Utility industry licensees would collectively share in the financial risk of a nuclear incident through payment of a retrospective premium to the nuclear insurance pools. In September 1976, the Commission published a proposed rule to set the premium at $5 million per reactor.[11]

If a nuclear incident results in damages exceeding the current $125 million primary insurance layer, each licensee of a large power reactor would be called upon to pay a prorated share of the damages in excess of the primary layer, up to the maximum of $5 million per reactor. The present $560 million limit on liability for a single nuclear incident would be retained until the combined primary and retrospective insurance layers reach $560 million. After that point, the combined liability coverage would rise with the increases in the primary and retrospective insurance layers. No ultimate dollar limit on liability would be set.

Low Level Radiation

The Congressional Research Service prepared for the Subcommittee on Energy and Environment (House Interior Committee) "Proceedings of a Congressional Seminar on Low-Level Ionizing Radiation."[12] The Seminar, cosponsored by the Environmental Study Conference and the Environmental Policy Institute, brought together scientists with a broad range of opinions about the effects of low level radiation, and Federal agency people with similarly diverse views. (It was held on May 4, 1976, and the Committee print was released in November.)

• Judicial

While there was little legislative activity resulting in statutes in 1976, there were a number of interesting and productive court cases. One, for example, addressed jurisdictional confusion between EPA and NRC, and another brought NRC licensing to a temporary halt. In addition, there were many challenges to individual power plants. Also important were conflicts over New York City's right to ban transportation of radioactive materials in its borders, and the State's corresponding request that air transport of special nuclear materials be halted.

EPA/NRC Jurisdiction

The Supreme Court ruled on June 1, 1976 that radioactive waste materials subject to NRC regulation are not "pollutants" under the Federal Water Pollution Control Act (Train v. Colorado Public Interest Research Group, Inc., 48 L.Ed.2d 434).[13] Therefore, EPA has no authority to regulate discharges of such wastes under the Act. Suit was originally brought under a provision authorizing citizen suits against the EPA Administrator for failure to perform a nondiscretionary duty. The Colorado Public Interest Research Group unsuccessfully contended that radioactive waste materials discharged from NRC licensed facilities were "pollutants," and thus subject to regulation by EPA and by individual States under EPA's permit program. The Court held that EPA had correctly disclaimed any authority under the Act to regulate the discharges.

Transportation

State of New York v. NRC (2nd Circ. Nos. 75–6115, 76-6022 and 76-6081). Three decisions issued by the District Court for the Southern District of New York during 1976 were appealed by the State of New York to the Court of Appeals for the Second Circuit. The central issue is whether the State can ban air transport of plutonium and enriched uranium.

United States of America v. City of New York (S.D.N.Y. No. 76–273). The State's request for a preliminary injunction against enforcement of a City Health Code provision on transportation of nuclear materials was denied on January 30, 1976. The Court found that no irreparable injury would occur, ending a decision on the merits of the case.

NRC is also involved in an attempt by several railroads to require the use of special trains for certain radioactive materials. In a matter before the Interstate Commerce Commission, the NRC contended that, insofar as the proceedings involve safety issues, they should be addressed to the NRC and/or the Department of Transportation.

Reprocessing and Waste Disposal

Two decisions handed down on July 21, 1976, by the United States Court of Appeals for the District of Columbia Circuit resulted in a temporary suspension of licensing by NRC. The two cases — Natural Resources Defense Council, Inc., v. NRC (D.C. Cir. Nos. 74-1385 and 74-1586) — related to the manner and degree to which the NRC considers the environmental impact of reprocessing and waste disposal in its reactor licensing process. The Court held that the rule governing such consideration (10 CFR 51.20(e)) must be more fully explained and documented than it was under then current practice. In August 1976, the Commission directed that a new and thorough staff analysis be undertaken of the environmental impact of fuel reprocessing and waste management associated with individual nuclear power plant licensing, to provide the explanation and documentation required.

Pending completion of the staff analysis, the Commission suspended issuance of new full-power operating licenses, construction permits and limited work authorizations. However, some types of licensing action — such as fuel loading, limited power testing, and construction permit amendments — were not affected by the decision. On October 8, the Court of Appeals stayed its mandate of July 21 and indicated that the Commission could continue licensing activities on the condition that it "shall make any licenses granted between July 21, 1976, and such time as the mandate has issued subject to the outcome of the proceeding herein."

On October 13, NRC announced a proposed interim rule — based on a newly completed staff analysis — dealing with environmental impacts of fuel reprocessing and waste management in licensing nuclear power plants. The interim rule was to be used for licensing only during the period required for completion of a public hearing process and publication of a final rule. The staff analysis concluded that environmental impacts of fuel reprocessing and waste management as they relate to individual nuclear plants continue to be small, even when impacts which were not completely accounted for in the past were considered. On November 5, 1976, the Commission announced that it was resuming licensing of nuclear power plants under the conditions set forth by the Court of Appeals on October 8. It did so on the basis of the breadth and quality of the new analysis of reprocessing and waste impacts, and its belief that there would be no substantial error in the staff's conclusion. (On March 14, 1977, NRC published the final interim rule at 42 F.R. 13883–7.)

Related court cases deal with energy conservation issues, incremental impact of the uranium fuel cycle, and ERDA's alleged failure to comply with the National Environmental Policy Act (NEPA).

Export Program and NEPA

Sierra Club v. NRC (D.D.C. No. 1867–73). Four environmental groups charged the NRC (originally the Atomic Energy Commission) and its Commissioners, and other Federal entities and their officials, with a series of alleged failures to comply with NEPA. Specifically, plaintiffs contended that the defendants have a "nuclear power export program" and that each of them must prepare an impact statement on the program as a whole and on each individual action taken in furtherance of the program. ERDA issued a final programmatic Environmental Impact Statement regarding the nuclear export program in March 1976. The suit was pending at year-end.

Radioiodine Reduction

York Committee for a Safe Environment v. NRC, 527 F.2d 812 (D.C. Cir. 1976). The Court of Appeals for the District of Columbia Circuit remanded this case to NRC for an individualized analysis of the cost and benefits of reducing routine radioiodine releases at Peach Bottom Atomic Power Station, Unit 2. Noting that the current level of emissions is low, the Court found that the public interest did not require suspension of the operating license. On January 26, the Commission ordered a Licensing Board to supervise the cost/benefit analysis.

Mixed Oxide Fuels

Natural Resources Defense Council, Inc., v. NRC (2d. Cir. Nos. 75-4276 and 75-4278). In a consolidated case, New York State and citizen groups sought review of the Commission's notice which set forth procedures for hearings on the Generic Environmental Statement on Mixed Oxide Fuel (GESMO). The notice also outlined agency standards for licensing activities related to the use of mixed oxide fuel prior to a decision on wide-scale use of plutonium recycle. On May 26, 1976, the Court of Appeals for the Second Circuit issued its decision, upholding in full both the GESMO hearing procedures and associated individual licensing procedures. However, interim licensing, except that for "experimental and feasibility purposes," was forbidden. This prohibition covers all separations, conversion, fuel fabrication, imports and loading of mixed oxide fuel in reactors unless it can be shown that the action is not related to commercial plutonium recycle. Current uses of mixed-oxide fuel remain unaffected. Allied General Nuclear Services has sought Supreme Court review of the Second Circuit's decision.

Price-Anderson Constitutionality

Carolina Environmental Study Group v. NRC (W.D.N.C. No. 73–139). In September 1976, a hearing was held in the U.S. District Court for the Western District of North Carolina, Charlotte Division, in a lawsuit in which the constitutionality of the Price-Anderson Act's limitation on liability provisions is being challenged. As of the end of the year, preliminary legal issues of standing and ripeness had not been resolved.

3. Executive Activities Pertaining to Public Exposure

• Comprehensive Activities

Guidance

Report on Controlling Planned Releases

In 1976 an expert international advisory group — including representatives from ERDA, NRC and EPA/ORP —prepared a final draft report setting forth principles for establishing limits for the release of radioactive material into the environment.[14] When finalized, the report will provide the basis for a unified international approach to controlling planned releases from nuclear fuel cycles. That approach will be consistent with current U.S. practice, as exemplified by new EPA/ORP standards for the uranium fuel cycle and NRC regulations for light-water-cooled reactors. Scheduled for completion in 1977, the report will be followed by consideration of specific numerical recommendations.

EPA/ORP's Standards for the Uranium Fuel Cycle

EPA/ORP published new final radiation protection standards for planned releases from the uranium fuel cycle on January 13, 1977.[15] Most steps involved in producing nuclear power are covered by the new standards, which apply to uranium mills, chemical conversion plants, isotopic enrichment facilities, fuel fabrication operations, nuclear power plants, and fuel reprocessing facilities.

The new standards are lower roughly by a factor of 20 than previous Federal Radiation Guides, which allowed 500 millirems maximum annual dose to the whole body and most organs, and 1,500 millirems to the thyroid, from all sources except medical activities and natural background radiation. New figures are shown in Table 4.2. These standards have the force of law, which the guides did not until they were translated by the regulatory agency into each license's specifications.

Unlike previous guides, the new limits consider the long term potential buildup of radiation in the environment, rather than annual exposure alone. They require that releases of krypton-85, not now controlled by industry, be reduced by a factor of ten by 1983. This requirement has worldwide implications, because krypton is distributed evenly throughout the world's atmosphere within about a year after its release. By the year 2000 only an estimated 30 percent of the world's krypton will be produced by the United States, but it is hoped that other countries will follow suit in limiting releases.

The standards also require, by 1983, a significant improvement in the control of iodine-129, which has a half-life of 17 million years. The required processes for retaining krypton-85 and iodine-129 are now in advanced stages of demonstration and should be available by 1983. The transuranic elements governed by these standards can be controlled using presently available processes.

NRC will implement the new standards by issuing detailed technical specifications and regulations for radioactive effluents from each of the specific facilities involved in the fuel cycle, as part of its normal licensing process. In this connection, EPA/ORP has concluded that the guidance issued in 1976 by NRC for control of effluents from individual light-water-cooled reactors will provide appropriate implementation of the standards at most existing reactor sites.

The EPA/ORP standards recognize the need not only to limit the public health and environmental impact of planned releases, but also to avoid unnecessary and precipitous disruptions in the orderly supply of electric power. For this reason, the regulations contain a variance procedure which may be used, on a temporary basis, if the NRC determines that its use will not pose a significant threat to public health.

TABLE 4.2

Proposed May 1975 Standards for Normal Operations of the Uranium Fuel Cycle

A. Individual Dose Limits	
1. Whole body	25 millirems/year
2. Thyroid	75 millirems/year
3. Other organs*	25 millirems/year
B. Limits for Long-Lived Radionuclides	
1. Krypton-85	50,000 curies/gigawatt-year
2. Iodine-129	5 millicuries/gigawatt-year
3. Transuranics**	0.5 millicuries/gigawatt-year

C. Variances

At the discretion of the regulatory agency (licensor) for temporary and unusual operating circumstances to insure orderly delivery of electrical power.

D. Effective Dates

1. Two years, except
2. 1983 for krypton-85 and iodine-129.

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*any human organ except the dermis, epidermis, or cornea.

**limited to alpha-emitters with half-lives greater than one year.

The NRC staff reviewed EPA/ORP's proposed environmental radiation standards for the uranium fuel cycle and light-water-cooled nuclear power reactors, and testified at EPA/ORP's public hearings on the subject in March 1976. NRC staff comments and subsequent discussions with EPA/ORP staff resulted in revisions in the proposed standards that would achieve the same level of environmental protection without unnecessary regulatory burdens on the NRC, which must implement the standards.

EPA/ORP's Environmental Analysis of Carbon-14

EPA/ORP prepared in several ways to propose standards for carbon-14 (C-14) discharges from the nuclear power industry. These particularly concern the Agency both because C-14 is very long-lived and because it becomes part of the carbon cycle, moving from the atmosphere and water to chemical structures of all life forms and back again. In the technical support documents for EPA/ORP's uranium fuel cycle standard, the Agency pointed out that "the potential for a long term impact on health due to carbon-14 released from fuel cycle operations was not recognized until the Agency considered environmental dose commitments from the industry in the course of developing these standards; thus, consideration of methods for limiting its release to the general environment is only now beginning." Specifically, in 1976:

— EPA/ORP continued to study C-14 sources and control systems for light water reactor facilities;

— public health considerations were discussed in a technical note published in July;[16]

— Science Applications, Inc. worked on a contract report to EPA which assesses C-14 control technology and costs for the light water reactor fuel cycle. After the final report is reviewed, it is expected to be published in 1977; the major conclusion is that caustic scrubbing is the best way to remove C-14 from waste gas streams and to leave it in a form compatible with permanent disposal conditions.

Types of NRC Standards

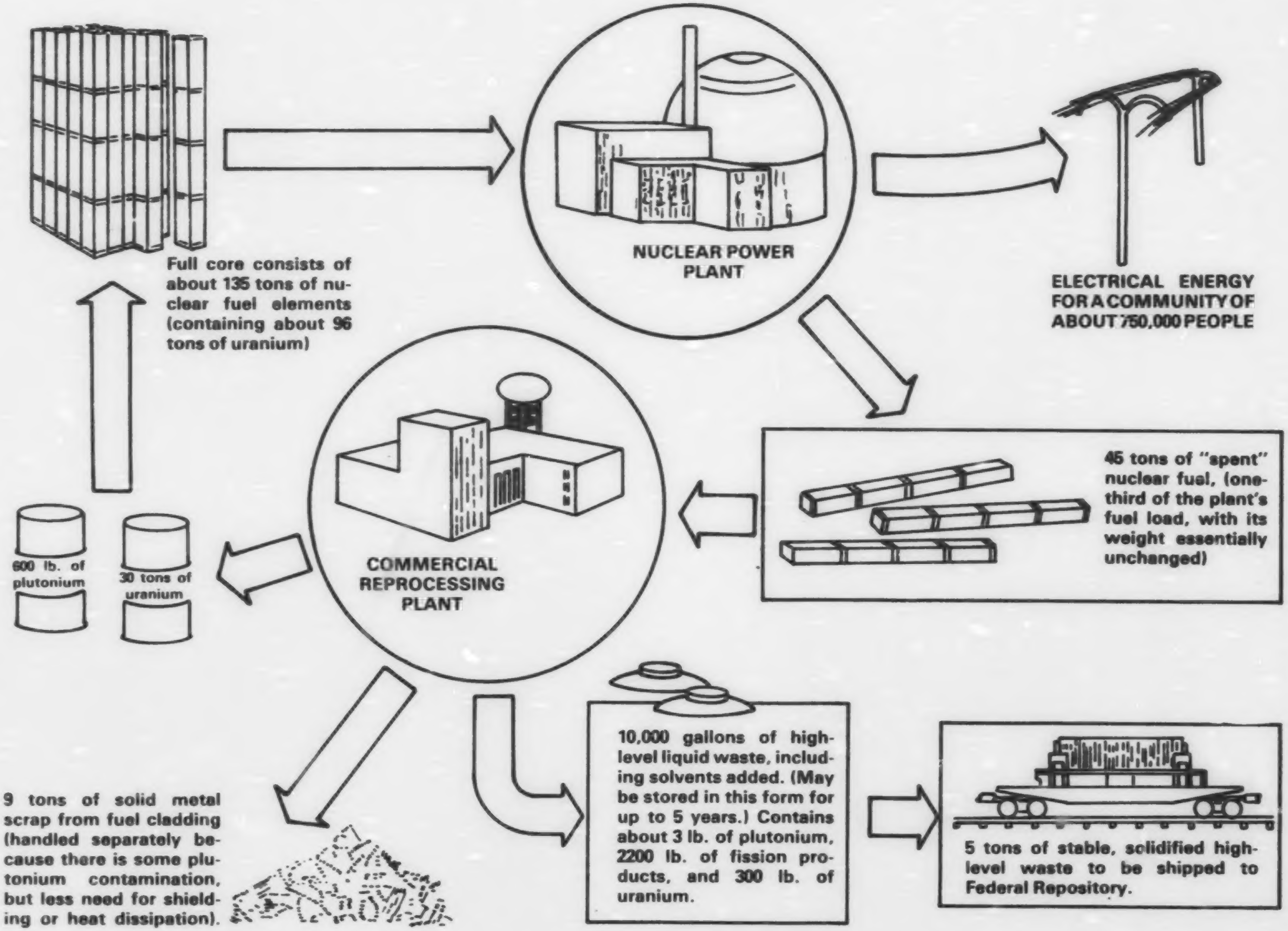
NRC standards are of two types: (a) regulations established by the Commission and published in Title 10, Chapter I, of the Code of Federal Regulations, which set forth requirements that must be met and (b) regulatory guides, developed to describe and make available to the public methods acceptable to the NRC staff for implementing specific parts of the Commission's regulations. In some cases, guides also delineate techniques used by the staff to evaluate specific problems or postulated accidents. In other cases, they provide guidance to applicants concerning information needed by the staff in its review of applications for permits and licenses. Many NRC guides refer to consensus standards (also called "national standards") which are developed by recognized national professional standards organizations, often with NRC participation.

NRC Environmental Guides

Regulatory Guide 4.11, "Terrestrial Environmental Studies for Nuclear Power Stations," was issued for comment in July 1976. This Guide provides information to applicants for NRC licenses on the types of ecological and land use surveys and environmental monitoring studies that should be considered (1) for evaluating the terrestrial environmental impact of proposed power plants, (2) for preparation of the construction permit application, and (3) during construction.

Regulatory Guide 4.13, "Performance, Testing and Procedural Specifications for Thermoluminescence Dosimetry: Environmental Applications," was issued for comment in November 1976. Thermoluminescence dosimetry (TLD) is widely used to measure levels of x and gamma radiation in the environs of NRC-licensed facilities. The American National Standards Institute has published a standard (ANSI-N545-1975) that specifies minimum acceptable performance of TLDs used for environmental measurements; outlines methods to test for compliance; and provides procedures for calibration, field application, and reporting. Regulatory Guide 4.13 endorses

TABLE 4.3


Full core consists of about 135 tons of nuclear fuel elements (containing about 96 tons of uranium)
NUCLEAR POWER PLANT
ELECTRICAL ENERGY FOR A COMMUNITY OF ABOUT 750,000 PEOPLE
45 tons of "spent" nuclear fuel, (one-third of the plant's fuel load, with its weight essentially unchanged)
COMMERCIAL REPROCESSING PLANT
600 lb. of plutonium
30 tons of uranium
9 tons of solid metal scrap from fuel cladding (handled separately because there is some plutonium contamination, but less need for shielding or heat dissipation).
10,000 gallons of high-level liquid waste, including solvents added. (May be stored in this form for up to 5 years.) Contains about 3 lb. of plutonium, 2200 lb. of fission products, and 300 lb. of uranium.
5 tons of stable, solidified high-level waste to be shipped to Federal Repository.

THE FUEL CYCLE ASSOCIATED WITH 1 YEAR'S OPERATION OF A TYPICAL 1000 ELECTRICAL-MEGAWATT NUCLEAR POWER PLANT.

the ANSI standard, subject to a number of provisions and qualifications.

NRC Review of Environmental Specifications

All nuclear power plant operating licenses that have been issued since January 1972 contain detailed environmental technical specifications which establish operating limitations and procedures and require monitoring programs to verify the anticipated environmental impacts of the plants. Considerable time, effort, and money are being spent by utilities to accumulate the required monitoring data. Therefore, NRC began reviewing in 1976 the degree to which environmental technical specifications adequately address real ecological problems, and how much conformance with them is actually determined by monitoring.

The major objectives of this review program are: (1) to evaluate preconstruction environmental studies; (2) to examine data collection, data analysis, and reporting format for operational monitoring; (3) to determine whether monitoring data validate thermal and ecological impact predictions made in the final environmental statement; and (4) to identify possible environmental impacts common to several power plants with similar hydrological and ecological profiles. The review will also assist in the development of ecosystem models that could be used by the NRC, as well as by applicants and licensees, in impact analysis.

NRC Effluent Guidelines

On April 30, 1975, NRC announced guidelines for levels of radioactive material in effluents from light-water-cooled nuclear power reactors to meet the criterion "as low as is reasonably achievable."

A major effort was made during the year:

— to improve the models used by the staff for estimating effluent levels, environmental dispersion, and dose calculations;

— to employ more realistic assumptions; and

— to develop guidance for licensees on implementing the cost-benefit analysis requirements contained in Section II D of the new regulation (Appendix I to 10 CFR Part 50).

This effort culminated in the issuance for public comment of many regulatory guides and technical reports.[17-23] They present calculation models and values of parameters acceptable to the NRC staff for calculating the average expected releases of radioactive material in liquid and gaseous effluents from normal operation, the dispersion of effluents in the atmosphere and different bodies of water and the associated radiation doses to man, and for performing the cost-benefit analysis required by Appendix I. A number of licenses have been required to add contol systems and radwaste equipment to meet the individual dose design objectives in the regulation.

NRC Regulations on Mixed Oxide Fuels

NRC prepared and issued for public comment proposed regulations covering the health, safety, and environmental aspects of possible wide-scale use of mixed oxides of plutonium and uranium to fuel nuclear power reactors.[24] The proposed regulations would (1) extend existing criteria for emergency core cooling systems to light water reactors fueled with mixed oxide fuel; (2) authorize amendments to licenses for the use of the composition of mixed oxide fuel covered in the "Generic Environmental Statement on Use of Mixed Oxide Fuel in Light Water Reactors" (GESMO), without the preparation of additional environmental statements; (3) modify regulations covering environmental effects of the nuclear fuel cycle to include the effects of mixed oxide fuel cycle activities; (4) permit the Commission to impose additional standards for the use of the composition of mixed oxide fuel not covered in GESMO.

NRC Regulations on Reporting Noncompliance

The Energy Reorganization Act of 1974 includes a section which requires certain individuals to report to NRC either a defect that could create a substantial safety hazard, or a failure to comply with a rule relating to such hazards.

To implement that section, the Commission published in March 1975 proposed amendments to its regulations.[25] They are intended to provide NRC with a new source of information to anticipate problems. A director or other responsible officer of a licensee (and many suppliers) would be subject to a civil penalty for failure to disclose relevant information.

Since this proposed new part was published, over 140 letters of comment have been received. The Commission at year-end was considering a summary of public comments received, alternative proposals for modifying the proposed Part 21, and information on existing Federal statutes and regulations tha[illegible]re similar to the proposed rule.

International Safeguards

NRC participated in developing and approving an agreement between the U.S. and the International Atomic Energy Agency (IAEA), which implements the U.S. offer to accept IAEA safeguards on nuclear activities (except for those which bear directly on national security). Concurrently, the safeguards are being applied in non-nuclear weapon States under the Nonproliferation Treaty. The U.S. first offered to take this step in 1976 during negotiations on the NPT, with the intention of making an agreement with the IAEA on safeguards procedures when they were being broadly applied in other industrial countries. The purpose of the offer was to demonstrate that the safeguards do not involve undue economic burdens or risk disclosure of proprietary information, thus assuring other countries that agreeing to the treaty would not place them at a commercial disadvantage.

Study Review

EPA/ORP conducted an intensive review of *Reactor Safety Study, An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants* (WASH-1400, NUREG-75/014), by Prof. Norman Rasmussen's study group.[26] Because it was the first really significant attempt to quantify the risks of nuclear power and because it is the principal reference on the subject, EPA/ORP made the Study one of its main efforts in generic reviews.

The resulting comments of EPA/ORP and its contractor, Intermountain Technologies, Inc., were published in a report.[27] Highlights follow:

1. EPA/ORP considers the Safety Study a major step forward in understanding and estimating the risks from nuclear power plants. EPA/ORP supports the Study, its concept, and the need for continuing the effort to arrive eventually at a reasonable consensus of risk associated with reactors.

2. The Study failed to address fully the health effects expected after an accident and to consider adequately a technical basis which includes a broad range of perspectives for estimating the incidence of the associated bioeffects. It appears that if late somatic health effects were adjusted in accordance with EPA/ORP's assessment of the numerical health risks, the estimates would increase. The potential change in the estimated early fatalities and injuries could not be determined by EPA/ORP from the information provided.

3. The Study appeared to have two deficiencies in the assumptions for evacuation as a protective action. The first involves the use of a constant 25 mile evacuation sector for all core melt accidents. This is at variance with present and planned practice and in some cases overestimates and in other cases underestimates the risk. The second set of deficient assumptions involves

the amount of time that persons would be exposed prior to and during evacuation and the evacuation speeds.

4. The Study has improperly or incompletely evaluated parameters used in determining certain accident event sequences and probabilities. The assessment of potential BWR reactor protection system failures was found to be the most significant case.

5. The Study report did not have an adequate description of the analysis of the consequences of the release of radioactive materials to the environment.

Subsequent meetings between the Reactor Safety Study staff and EPA/ORP staff resulted in agreement that (1) the EPA/ORP position on calculation of late somatic health effects would result in a factor of four increase in such calculated effects, (2) the Study's model for evacuations was adequate for the Study's purposes, and (3) the assessment of potential BWR reactor protection system failures was the only case-specific parameter whose reevaluation appeared to have the potential to change the overall risk estimates significantly.

Environmental Impact Statements

While many agencies — often several dozen — comment on Environmental Impact Statements, EPA has primary responsibility. Therefore, and because of space limitations, only EPA/ORP responses are summarized here.

Liquid Metal Fast Breeder Reactor

Description: The proposed Clinch River facility near Oak Ridge, Tennessee is to be a 975 megawatt (thermal) demonstration project that includes a liquid metal fast breeder reactor (LMFBR), fueled with a mixture of plutonium and uranium oxides. The Environmental Report prepared by ERDA for Clinch River was reviewed and a Draft Environmental Statement was issued for public comment by the NRC on February 12, 1976.[28] Numerous comments were received and considered in preparation of the Final Environmental Statement, which was issued in December 1976.

ERDA conducted the environmental assessment of the LMFBR program and issued its Final Environmental Statement on December 31, 1975. In response to contentions filed by intervenors, the need for an independent staff review of the ERDA program statement was considered by the Commission and rejected in August 1976.

EPA/ORP Response and Status: The ERDA Final Environmental Statement fully reflected EPA/ORP's 1975 comments and responded satisfactorily to them.

Floating Nuclear Power Plants

Description: An NRC staff Draft Environmental Statement was published in December 1975 covering the generic issues pertaining to the proposed siting of floating nuclear plants in the coastal regions of the Atlantic Ocean and the Gulf of Mexico.[29] The floating nuclear plant was conceived by the electric power industry some years ago as an alternative to land siting; its potential advantages include freedom from earthquake motions, an abundance of cooling water, and a relative isolation from populated areas.

EPA/ORP Response and Status: EPA/ORP rated the NRC Statement inadequate, and presented its criticisms in testimony before the House Subcommittee on Energy and the Environment on July 27, 1976.[30] Deficiencies cited were: (1) inadequate treatment of inshore siting options, (2) inadequate treatment of siting criteria, (3) lack of discussion of long term and cumulative impacts of a projected industry, and (4) lack of justification of eight plants for the first increment of production.

When the Final Environmental Statement was issued by NRC on October 1, 1976, EPA/ORP found it unresponsive to the comments and so informed the NRC and Council on Environmental

Quality. Resolution of EPA/ORP's concerns is now underway.

Mixed Oxide Fuel

Description: In August 1976, NRC released NUREG-0002, titled "Final Generic Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in Light Water Cooled Reactors — Health, Safety and Environment," or GESMO-1.[31] The final Statement, which consists of five volumes and contains a total of 1700 pages, includes the NRC staff responses to the comments received on the 1974 Draft Environmental Impact Statement.

The principal staff findings based on health, safety and environmental — but not safeguards — considerations, were as follows:

— The safety of reactors and fuel cycle facilities would not be affected signficantly by recycle of fissile materials.

— Adverse nonradiological environmental impacts resulting from recycle of fissile materials from spent fuel would actually be slightly less than those from a fuel cycle that does not reclaim residual fuel values.

— Plutonium recycle would extend uranium resources and reduce enrichment requirements, but would introduce the need for reprocessing and fabrication of plutonium-containing fuels.

— While there are uncertainties, wide-scale recycle would be likely to have economic advantages compared to a fuel cycle that does not reclaim residual fuel values.

— Differences in health effects attributable to alternative fuel cycles would be too slight to provide a significant basis for selection among the alternatives.

— No waste management considerations were identified that would bar recycle of recovered uranium and plutonium.

EPA/ORP Response and Status: EPA/ORP's review concentrated on technical aspects of the Statement, particularly the comparison of impacts of mixed oxide fuel versus conventional enriched uranium fuel. Among other points, the Agency contended that the technology necessary to close the fuel cycle has not been finally established, and, until it is, the economic basis for plutonium recycle would be speculative. Recommendations included a demonstration or pilot project subject to thorough consideration of the safeguards issues.

Nuclear Power Export Activities

Description: In April 1976 ERDA — with the collaboration and endorsement of the Department of State, the NRC, and the Export-Import Bank — prepared a Final Environmental Statement on U.S. Nuclear Export Activities (ERDA 1542).[32] The Statement's purpose was to assess a wide range of costs and benefits of the Atoms for Peace program to spread nuclear power to other countries, from its inception in 1954 through the year 2000. The Statement considered alternatives to current policies, from complete termination of exports to continuation of existing policy with upgraded technology to minimize environmental impacts.

EPA/ORP Response and Status: EPA/ORP recommended that, since return of exported U.S. fuel for reprocessing was an alternative considered in the Draft Statement, the final version should address the environmental impacts that could result. While this was not done in the Final Statement, ERDA later agreed that a separate assessment would be made if reprocessing becomes part of U.S. policy.

Expansion of Uranium Enrichment Capacity

Description: ERDA's Final Environmental Statement[33] considers the general question of expanding U.S. uranium enrichment capacity, a move ERDA considers necessary to maintain the option of constructing and operating additional nuclear reactors. In addition to discussing the low level environmental releases of radiation and issues like water consumption, the Statement covers economic and social costs.

EPA/ORP Response and Status: In addition to addressing the adequacy of the Statement as presented, EPA/ORP attempted to apply a perspective of priority setting for overall nuclear fuel cycle needs. Among its more important conclusions were:

— a nuclear enrichment program can be conducted with an acceptable environmental impact.

— reassessment of nuclear fuel cycle priorities is necessary to facilitate a smooth domestic program.

— definition and classification of enrichment wastes and of associated waste management practices should be improved.

— enrichment plant dose assessment must be done on a site-dependent basis using local meteorology.

Portsmouth Gaseous Diffusion Plant Expansion

Description: ERDA prepared a Draft Environmental Statement in November 1976 to assess the Portsmouth Gaseous Diffusion Plant Expansion.[34] To accommodate U.S. needs for nuclear fuel as well as those of foreign customers, ERDA concluded that an additional plant would be required to ensure an adequate supply after 1985, and chose the Portsmouth site. While the Statement was being reviewed by EPA/ORP, the importance of the proposed action was enhanced as the new Administration put increasing emphasis on expanding enrichment capacity to achieve nonproliferation goals.

EPA/ORP Response and Status: EPA/ORP questioned whether possible alternatives had been given adequate consideration, and suggested that an expansion facility could be built at a later date if actually needed, using energy- and water-saving centrifuge technology rather than diffusion. Also, the Agency contended that analysis of the regional impact was insufficient. Since EPA/ORP's comments were submitted, ERDA has proposed an open season for enrichment contracts, indicated that some additional lead time is available, and that the eventual expanded facility will probably use centrifuge technology.

Brookhaven National Laboratory

Description: ERDA's Draft Environmental Statement[35] addresses the principal pathways from Brookhaven: releases of waste to the atmosphere and a nearby river, and direct exposure both from the facilities themselves and from transportation of waste materials. Operations thus far have had no perceptible impact on the offsite environment.

EPA/ORP Response and Status: EPA/ORP concluded in its review that:

— the present operation and planned expansion at Brookhaven can be accomplished with an acceptable environmental impact.

— the Final Statement should qualify the radiological impact of shipping spent reactor fuel in relation to the actual shipping situation, instead of using a generic approach.

— the recharge basins, loss of sewage input, and leaching from the land fill represent potential means of groundwater contamination. The Agency asked for some additional information, and rated the Draft "insufficient information" and the action proposed as "lack of objections."

Enforcement

Inspection Types

Planned NRC inspections are based on a defined program expressed in detailed inspection procedures, and are accomplished at prescribed intervals by NRC regional inspectors. Their principal objective is to provide reasonable assurance that licensed activities are conducted safely and in compliance with NRC requirements. This objective is met through selective examination of systems and functions, both administrative and physical, that have an impact on the safety and protection provided by each licensee.

Reactive NRC inspections respond to particular conditions or events which may affect the public's health and safety. Information on such conditions or events comes to NRC through notification by an applicant, licensee, contractor or supplier, or as a result of allegations by a member of the public. Each licensee is required to report any abnormal condition or event to the Commission, thus providing for continuous NRC monitoring of licensee operations. Compliance with these reporting requirements is examined during the planned on-site NRC inspections.

Action Taken

Several threshold levels of NRC action are provided to allow flexibility in the enforcement action response to reports of noncompliance:

— Written "notices of violation" are provided for a spectrum of matters where severity and punitive considerations are below the threshold of orders and civil penalties.

— Civil monetary penalties are provided as an incentive for licensees to assure compliance on a continuing basis. They are considered for licensees with chronic, deliberate, or repetitive items of noncompliance, generally where a "notice of violation" has not been effective. Civil penalties may also be imposed for certain first of a kind violations.

— Orders to "cease and desist" operations, or for modification, suspension, or revocation of licenses are used to deal rapidly and conclusively with licensees who do not respond to civil penalties or to deal with violations that constitute a significant threat to public health and safety or to the common defense and security.

During the period July 1, 1975 through September 30, 1976 a total of 15 civil monetary penalties were imposed upon licensees by NRC in order to enforce compliance with NRC rules and regulations.

Confirmation of Monitoring Measurements

NRC for several years has enlisted the cooperation of the National Bureau of Standards, the Energy Research and Development Administration, and State health and environmental agencies to provide corroborative evidence of the environmental and effluent radioactivity measurements submitted by licensees. This system provides some specific evidence for the evaluation of the capability of licensees to perform radioactivity measurements. The Health Services Laboratory (HSL) of the ERDA Idaho National Engineering Laboratory functions as the NRC reference laboratory in such matters, and NRC inspectors regularly compare licensee effluent measurements with those made by HSL on identical effluent samples.

The State agencies assist in long-term, repetitive sampling to evaluate licensees' overall environmental programs. At the end of 1976, the 19 States participating in this program were Alabama, Arkansas, California, Colorado, Connecticut, Florida, Illinois, Maine, Maryland, Michigan, Minnesota, Nebraska, New Jersey, New York, Pennsylvania, South Carolina, Vermont, Virginia, and Wisconsin. For most States this arrangement is under written contract, with NRC providing these States with funds, technical support and training to assist in improving their analytical capabilities.

Standard Review Plans

NRC's Standard Review Plans for safety reviews were completed during 1975 and fully implemented during 1976. The Plans describe the process by which the NRC staff determines that a proposed design provides adequate protection of the public health and safety. The primary purposes of the Plans are to improve the quality and uniformity of staff reviews, to stabilize the safety review process, and to present a well-defined base from which to evaluate proposed changes in the scope and requirements of reviews. Another important goal is to assure that only essential requirements are imposed on license applications.

Studies

NRC's Risk Assessment Studies

NRC is exploring ways in which the probabilities and risk assessment techniques developed in the *Reactor Safety Study* (WASH-1400) can be implemented in the regulatory process and applied to help resolve both specific and generic technical issues. Also, a computer code has been developed for detailed analysis of nuclear power plant reliability data. The code may be used to calculate the sensitivity of system unavailability to variations in test-related characteristics and to design changes.

Several studies were concluded to provide information needed in risk assessment and licensing. These included: (1) one phase of a study to formulate a methodology, based on WASH-1400 techniques, to examine the risk to the public of reprocessing of nuclear fuels; (2) analysis of the effect of engineered safety features on the risk of hypothetical Liquid Metal Fast Breeder Reactor accidents; and (3) an analysis of data on fires at nuclear power plants to be used in the development of a risk assessment.

Cost/Benefit of Reducing Exposures

NRC and EPA/ORP began to cooperate on defining the health benefits of reducing radiation exposures of the general population from nuclear facility effluents, soliciting public and industry input. The results will be used by NRC to improve the bases for conducting the cost-benefit analysis required by its regulations establishing as low as reasonably achievable population doses.

Doses Associated with Power Generation

To compare the internal radiation doses associated with nuclear power to those from conventional systems, the National Institute of Environmental Health Sciences sponsored a study at New York University. It will evaluate effects of radionuclides on a local population and on the global community.

EPA/ORP Radiation Studies at Nuclear Facilities

EPA/ORP continued its special field studies at selected typical nuclear facilities. In addition to helping develop measurement techniques and validate dose computational models, the studies are useful in characterizing effluents and determining whether technology to control nuclear wastes can meet design specifications. Some of the studies completed or in progress in 1976 were:

— *Oyster Creek Nuclear Power Plant*: EPA/ORP published a report of a study[36] conducted jointly with NRC. Data were gathered to validate a dose model that estimates the external, whole body, cloud gamma dose to exposed populations. In addition, the field study team evaluated programs to measure discharged radionuclides and interpret results in terms of radiation exposure, and examined the movement of radionuclides through the environment under routine conditions.

— *Quad Cities Nuclear Power Station*: A draft report was prepared during 1976 of a continuing joint EPA/NRC study of the iodine-131 to milk pathway at a boiling water reactor. Measurements included release rates and concentrations of iodine-131 in air, grass and milk.

— *Monticello Nuclear Generating Plant*: EPA/ORP, the Minnesota Department of Health, Northern States Power Company and NRC collaborated on collecting data to validate a dose model. Results were published in 1976.[37]

— *G.E. Fuel Fabrication Plant*: EPA/ORP completed a study to characterize the stack effluents of a larger fuel fabrication facility, and to learn about types of radionuclides discharged and about significant environmental exposure pathways. As stated in a draft report to be published in 1977, these data will be used to validate dose models for use in future estimates of individual and population doses.

— *Puget Sound Naval Shipyard*: EPA/ORP published the results of its study of the Shipyard, designed to locate, identify and measure any radionuclides in the port or its environment due to nuclear ship activity, and then to analyze any hazard resulting from them.[38] Researchers could find no significant levels due to nuclear powered ships.

— *Browns Ferry Nuclear Power Plant*: Design and evaluation of an ambient radiation monitoring program was the major objective of a joint study begun by EPA/ORP, the Alabama Division of Radiological Health, the Tennessee Valley Authority and others. Only background data was gathered before the plant was shut down temporarily, but the study will resume in 1977.

• Waste

Administration

An Interagency Task Force on Commercial Nuclear Wastes was formed and chaired by the Office of Management and Budget with participants from the Council on Environmental Quality, EPA/ORP, ERDA, the U.S. Geological Survey, and NRC. The Task Force worked on the following:

— identifying the respective roles of ERDA, EPA/ORP, and NRC in the area of nuclear waste management,

— determining the current timetable for the agencies' waste management reports, decisions, and research and development results,

— working with the agencies to secure the clarification of their roles and timetable changes needed to assure adequate scheduling of these reports, decisions, and research and development results, and

— identifying alternative actions that might be taken to clarify roles of the agencies, if any clarification is needed.

The Task Force did not reconsider program matters such as the adequacy of safety analyses, the validity of technologies involved in all aspects of the waste management issue, or the acceptability of environmental criteria.

Guidance

In January 1976, the NRC set up a task force to define goals against which nuclear waste management programs could be evaluated. The task force began by interviewing a wide range of individuals from industry, conservation groups, and agencies involved in waste management. The interviews pointed up the complexity of the issues, which span social, political, institutional, and ethical problems.

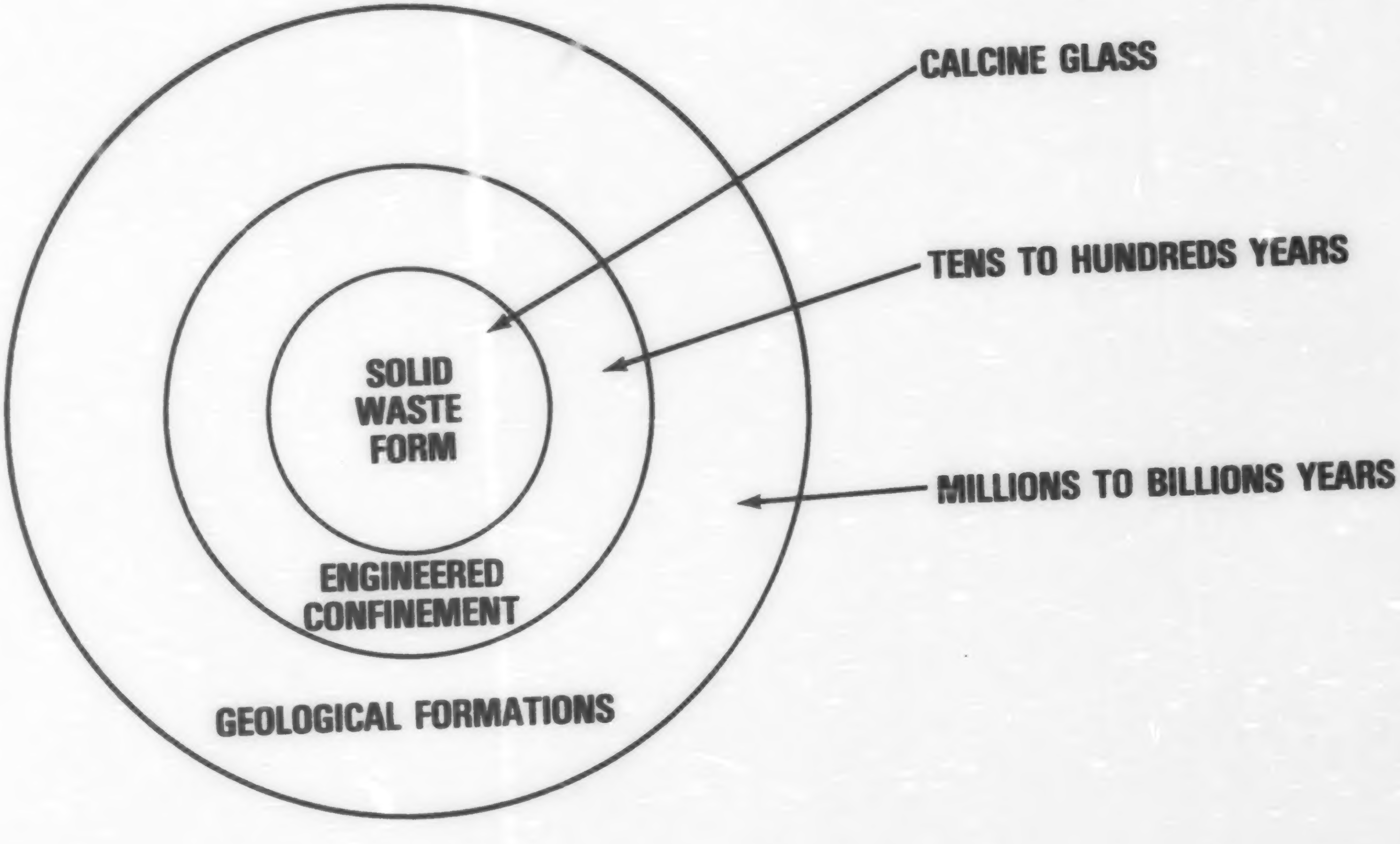
The task force identified several time horizons pertinent to dealing with nuclear wastes: the coming decade, the next few centuries, and the next few hundred millenia. NRC's statement of goals and objectives will address each of these. Ensuring long term safety was universally cited as the most important requirement, yet judgments about what would be adequate varied widely—understandably so, because of the extended time periods involved.

The recommendations of the task force were conveyed to the Commission early in 1977, following an oral report at the Conference on Public Policy Issues in Nuclear Waste Management at Chicago in October. After considering the policy issues and priorities that should be assigned to the various goals, the Commission will request public comments on recommended goals and will establish policy based on the report and the comments received.

High Level Waste Criteria

Development work supporting the formulation of performance criteria for solid matrices for high

BARRIERS TO THE ENVIRONMENT



CALCINE GLASS

TENS TO HUNDREDS YEARS

MILLIONS TO BILLIONS YEARS

SOLID
WASTE
FORM

ENGINEERED
CONFINEMENT

GEOLOGICAL FORMATIONS

level wastes was completed by Lawrence Livermore Laboratories and the University of Arizona under contracts with NRC. Based on this work, preparation of a proposed regulation was initiated.

Preliminary identification and scheduling of the standards required for the regulation of all categories of licensed wastes is nearing completion. Similar efforts directed toward scheduling the development of licensing methodologies and predictive models are underway. Regulations governing the performance of high level waste solids, setting forth waste classifications for regulatory purposes, and setting forth site suitability criteria for high level waste repositories are scheduled to be proposed for public comment in 1977 and 1978. The addition of a new part to the Commission's regulations specifically for waste management facilities and operations is also being considered.

West Valley Wastes

A policy statement issued by the former Atomic Energy Commission in 1971 (Appendix F to 10 CFR Part 50 of NRC regulations) provided that high level radioactive liquid wastes produced at reprocessing plants must be (1) converted to an approved solid form within five years, and (2) shipped to a Federal repository within 10 years after separation of the fission products from the irradiated fuel. The rule provided that its application to existing wastes (produced by the Nuclear Fuel Services plant at West Valley, N.Y., the only spent fuel reprocessing plant to be licensed for operation) would be the subject of a further rulemaking proceeding.

The NRC staff published in April 1976 a report concerning disposition of the liquid high level waste currently being stored at the closed-down facility at West Valley.[39] The waste includes 600,000 gallons of neutralized (non-acid) high level waste and 12,000 gallons of acid from high level waste, both by-products of spent reactor fuel reprocessing from 1966 to 1972. The report, "Alternative Processes for Managing Existing Commercial High-Level Radioactive Wastes" (NUREG-0043), discusses the nature of the wastes and reviews the available technology that may be applicable.

Decommissioning Criteria

In the waste management area, technical studies were underway at the Battelle-Pacific Northwest Laboratory to develop decontamination and decommissioning criteria for light water reactors and for fuel cycle facilities, with initial reports scheduled for completion in early 1977. These will assist in developing decommissioning regulations and regulatory guides.

Environmental Impact Statements

Reprocessing and Waste Management

Description: Supplement 1 to WASH-1248, "Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle" (NUREG-0116) was published by the NRC in October 1976.[40] It was a result of the July 21 decision by the U.S. Court of Appeals, D.C. Circuit, remanding the reprocessing and waste management portions of the fuel cycle rule (see above). The Supplement considers two fuel cycles: uranium-only recycle, and the no recycle case. It presents a full discussion of spent fuel reprocessing and waste management impacts, and is based on a thorough survey of the available data. In general, the Supplement indicates that the available data are adequate for a quantitative assessment of impacts from normal operations of all parts of the reprocessing and waste management system. Accidents were analyzed for most components of the complete system, but the basis for these analyses in the literature were varied, and all accident sequences could not be analyzed. Even when impacts not completely accounted for previously were considered, the NRC report found that environmental impacts of fuel reprocessing and waste management at individual nuclear plants continue to be small.

EPA/ORP Response and Status: EPA/ORP concluded that the report did not meet the stated purpose of clarifying and elaborating on the environmental impacts associated with the management of nuclear fuels and wastes. More substantive information and data were needed to support the impact assessments presented, and EPA/ORP questioned a number of the assumptions, approaches, analyses and references used by NRC. Concern also focused on the use of a relative hazard index, failure to recognize problems of milling and mining, and presentation of environmental impact from radiological releases and problems associated with low level wastes.

Waste Management Operations at the Hanford Reservation

Description: The Final Environmental Statement[41] ERDA issued in December 1975 covered current waste management operations at Hanford and the program to convert stored and newly generated high level waste from a liquid to a salt cake form. Alternatives include additional treatment of waste streams, calcining the wastes, or holding them in liquid form.

EPA/ORP Response and Status: EPA/ORP found that the Final Statement was responsive to the concerns it expressed with regard to the Draft Statement, and that there is adequate emphasis on improved waste management practices and ultimate disposal.

Commercially Generated Radwaste

Description: A *Federal Register* notice of October 1, 1976[42] included an outline for a proposed Generic Environmental Impact Statement for the management of commercially generated radwaste.

EPA/ORP Response and Status: EPA/ORP responded that the outline provided insufficient coverage to such areas as risk benefit consideration, alternatives, a detailed assessment of potential accidents, and whether all wastes from both fuel cycle and non-fuel cycle operations would be covered.

Waste Management Operations at Idaho National Laboratory

Description: ERDA's October 1976 Draft Statement[43] assesses the impact of continuing waste management operations at the Idaho National Engineering Laboratory. Currently, high level waste is calcinated into solids and stored in steel bins in underground concrete vaults, where it will remain until a terminal storage method is developed. The Statement concludes that the total body dose to people resulting from the Idaho operations is small compared to natural background.

EPA/ORP Response and Status: EPA/ORP felt that the hydrogeologic information available could be improved to perform a more comprehensive evaluation of the potential for environmental damage caused by stored waste. Also emphasized were the importance of (1) eliminating reliance on soils to remove radioactivity from liquid wastes discharged to the ground, and (2) placing more emphasis on determining an acceptable disposal form and method for high level wastes.

ERDA Waste Conferences

ERDA sponsored two meetings on radwastes, in part to incorporate public comment and views in the drafting of its Environmental Impact Statement on commercial waste management. The first, billed as an international technological seminar on waste handling, was attended by over 600 people from twelve nations, while the second focused on environmental and societal ramifications. (The latter was cosponsored by NRC, EPA, the National Science Foundation and the Council on Environmental Quality.)

Barnwell Fuel Receiving and Storage Station

Description: Construction of Allied General Nuclear Services' separation plant at Barnwell, S.C., is virtually completed; however, work on the projected plutonium conversion and waste solidification facilities at Barnwell has not yet begun. The hearing on the application to license the operation was continuing at the end of 1976, but was limited to safety and environmental issues.

The NRC's Final Environmental Impact Statement, which was introduced into the hearing record, has been supplemented by a Draft Statement dealing with impacts from the full range of activities expected to be conducted at Barnwell and vicinity as well as with krypton-85, tritium and carbon-14 gas removal and collection technology.[44] Comments on the Draft Supplement were received but a Final Supplement had not been issued by year-end. A second Supplement, dealing with the final cost benefit analysis and with safeguards, is planned when a licensing basis is established, that is, after the Commission's decision on recycle and reprocessing.

EPA/ORP Response and Status: In its review, EPA/ORP classified the project as "environmental reservations," finding an inadequate response to comments on the Draft Statement regarding effluent limits for discharging radioactive waste liquid. It had been EPA/ORP's understanding throughout the lengthy licensing process for the Barnwell facility that no radioactive waste discharges to the receiving waters were planned. The issues requiring clarification include: (1) whether or not there are planned liquid releases for the facility, (2) bases for any liquid waste concentration limits that may be applied to planned discharges, and (3) specific bases for any liquid waste concentration limits including 15% of applicable regulation concentrations that have been or will be applied for abnormal occurrences.

High Performance Fuel Laboratory at Richland, Washington

Description: The Draft Statement[45] addresses potential impacts of the construction and operation of the High Performance Fuel Laboratory, a pilot scale facility used by ERDA to support the fuels development effort in the breeder reactor program. Some of the subjects touched on are effluent and environmental monitoring and measuring, waste handling systems, site security, regional hydrology and alternative sites.

EPA/ORP Response and Status: EPA/ORP noted that the ERDA Statement did not demonstrate that waste water discharges would not signifcantly affect the water supply. In general, the Statement failed to present a clear picture of the waste water disposal system and the water supply system for the facility; it appears that sanitary wastes would be discharged to the ground after being processed at a sewage treatment plant.

Enforcement and Licensing

Licensing ERDA Facilities

While ERDA has the task of developing and demonstrating technologies for storage and disposal of high level nuclear wastes, the Energy Reorganization Act of 1974 assigns NRC the responsibility to license and regulate the facilities to be employed for the safe storage and/or disposal of these wastes.

The NRC is actively preparing for the licensing of these ERDA facilities. Factors being considered in the development of licensing procedures include assuring the protection of the health and safety of the public, the timely development of the facilities, and obtaining public participation to the fullest extent possible. With these factors in mind, the preparation of a licensing procedure which will provide for effective NRC regulation is well underway.

The NRC licensing procedures will provide for an independent assessment of proposed ERDA waste management facilities. A study under NRC direction has been initiated at Sandia Laboratories to develop the procedures, methods, and guidelines which will be used for assessing the risks and evaluating the acceptability of proposed geologic storage facilities. The evaluation of performance will be in terms of meeting NRC goals and objectives for waste management in areas including safety, environmental, technical, societal, economic, and public involvement factors.

NRC Oversight of Waste Disposal

During the year the NRC established a task force to reassess the roles of Federal and State governments in the regulation and operation of commercial low level radioactive waste burial grounds. This was done to meet a commitment to the Joint Committee on Atomic Energy and to respond to recommendations of the House Committee on Government Operations. The task force visited the various burial sites. It also held meetings with management representatives in the respective States to discuss each State's experience and obtain its views. A report containing the task force's findings and recommendations was in preparation at year-end.

Studies

EPA/ORP Research on Burial Sites

EPA/ORP is working to determine the impact of ground disposal of radioactive wastes on a practical, field-oriented basis by conducting studies at operating commercial burial facilities. Thus far, studies have been conducted, in close cooperation with the States of New York and Kentucky and the U.S. Geological Survey, at the Maxey Flats, Kentucky and West Valley, New York burial sites. At Maxey Flats, preliminary environmental pathways and evaporation studies have already been completed, and preliminary hydrogeological and radiological studies are in process; at West Valley, EPA/ORP has finished a preliminary radioactivity migration study and is now in the second year of a four-year detailed environmental pathways study. In 1977 the Agency hopes to extend the studies to include other burial sites.

In addition, EPA/ORP is conducting or sponsoring several smaller studies aimed at specific segments of the land burial problem, such as determining what wastes are buried in the burial grounds; factors which affect the retention of radionuclides by soil; potential improvements in site engineering, operations and water management; and development of criteria for selection of a burial site. .

Specifics on sample programs follow:

— *Characterization of reactor-generated low level radwastes*: EPA/ORP continued to fund a study investigating the radionuclide makeup of light water reactor radioactive wastes presently being consigned to shallow land burial. Chemical analyses were made of spent ion exchange resins, evaporator concentrates, and filter sludges for specific radionuclides. Waste samples from four reactors were analyzed to determine gross alpha, beta and gamma activities. A report will be issued in 1977.

— *Environmental survey of packaging for solidified low level radwastes*: EPA/ORP supported a study to analyze packaging methods and techniques for solidified low level radwaste, simulating environmental conditions present in shallow land burial and deep ocean disposal. Considerations will include physical, chemical and radioactive properties which affect the durability of the packages, and practices currently followed both in the U.S. and in other countries.

— *Inventory and projections of low level radwastes for burial at commercial facilities*: EPA/ORP is preparing a report of the inventory (through June 1976) of low level radioactive wastes buried at the six commercial facilities. These data update a 1974 report and were compiled through arrangements with various State regulatory agencies. A projection or prediction of future waste volumes for comparison with existing capacity will be included.

NRC Site Reassessment

The reassessment of existing sites involves interrelated activities by NRC, the States, and other Federal agencies—including some parts of the NRC staff review of the Federal/State programs; Agreement State and NRC licensing and inspection programs; work of the NRC in-house task force on criteria; a State bonding task force report; U.S. Geological Survey and EPA/ORP data base site studies; and interagency task force efforts.

As part of the Commission's ongoing program to reexamine the bases for the management of radioactive wastes, and in response to Congressional concerns, the NRC undertook a study of Federal/State programs for the regulation and operation of the commercial low level burial facilities. The NRC staff study was a concentrated effort to assess the overall programs for these sites and to identify needed corrective actions.

During July and August, 1976, NRC staff met with representatives from the States of Illinois, Kentucky, Nevada, New York, South Carolina, and Washington. (A commercial disposal facility is located in each of these States.) The purpose of the meetings was to discuss the States' experience and views concerning the regulation and operation of commercial low level radioactive waste burial facilities. The views expressed at these meetings were incorporated into the ongoing staff study. The NRC staff also visited five of the six existing commercial sites during this time.

GAO Report

In June 1974, the U.S. General Accounting Office (GAO) initiated a review of nuclear waste burial grounds. In January 1976, the GAO issued its report to Congress, entitled "Improvements Needed in the Land Disposal of Radioactive Wastes—A Problem of Centuries."[46] The report dealt with both commercial and ERDA operated burial activities. The GAO made several recommendations to the NRC concerning the need for comprehensive studies of waste disposal sites, development of site selection criteria, improvements in monitoring programs and development of long term care requirements.

The most broad ranging GAO recommendation was for studies of existing commercial and ERDA sites to evaluate their ability to retain radioactive waste. Then, on the basis of those studies, site selection criteria would be developed for determining the long term suitability of existing disposal sites and for selecting future sites. Full implementation of all the recommendations will involve a number of Federal agencies and State groups who have overlapping charges and ongoing studies.

An informal interagency working group to deal specifically with shallow land burial and with the implementation of the GAO recommendations has been established following an NRC initiative. The group consists of representatives of NRC, ERDA, EPA/ORP and USGS, plus a representative of the National Conference of Radiation Control Program Directors to provide input from the States. The group has agreed to define areas of responsibilities, to coordinate the timing of programs, and to see that the GAO recommendations are fully implemented, while minimizing duplication of effort.

Status Report

The Federal Energy Administration compiled a Status Report on Management of Commercial Radioactive Nuclear Wastes, released May 10, 1976. It reported on what it described as a comprehensive government waste program plan, including:

— extensive environmental assessments and impact statements, prior to decisions on reprocessing, recycle, waste forms, storage modes and packing criteria;

— selection of specific technologies for waste solidification and of waste terminal storage sites;

— completion of environmental, safety and related regulatory standards, criteria and reviews to assure acceptable radioactive waste management practices;

— an interagency task force to coordinate these activities among the responsible Federal agencies.

• Spent Fuel

Environmental Impact Statements

NRC evaluated the environmental impact of handling, shipping and storing spent fuel during the ten years or so when interim storage will be required regardless of any fuel cycle decisions. A Draft Generic Environmental Impact Statement covering this evaluation will be published in August 1977, and the Final Statement and any possible rulemaking or other guidance on spent storage are anticipated later.

Licensing and Enforcement

Since no reprocessing of spent fuel from light water reactors is taking place pending NRC's resolution of the issues regarding recycle, disposition of the growing inventory of spent fuel has become a problem for an increasing number of utilities. Typical storage capacity at a reactor is about one and one-half core loads, or six years of accumulated spent fuel. Nuclear utilities have been contacting NRC regarding storage capacity at their nuclear power plants in increasing numbers. Thirteen applications, letters of intent and other indications of interest in increasing storage capacity were received during calendar year 1975, and an additional 17 during calendar year 1976. By December 31, 1976, the NRC had approved 18 requests.

• Transportation

Guidance

Irradiated Fuel Packaging

Spent (irradiated) nuclear fuel is transported off site in shipping casks specially designed to contain the radioactive fuel assembly materials during normal and postulated design accident transportation conditions. Two regulatory guides which outline the NRC staff recommendations for design loading conditions and design criteria for the shipping casks were under development in fiscal year 1976.

Plutonium Packaging

Public Law 94-79 requires the NRC to prohibit its licensees from transporting plutonium by air until it has certified to the Joint Committee on Atomic Energy of the Congress "that a safe container has been developed and tested which will not rupture under crash and blast testing equivalent to the crash and explosion of a high-flying aircraft." Except for plutonium contained in a medical device designed for individual human application (like a cardiac pacemaker), the restriction applies to all air transport of plutonium.

Qualification criteria are being developed to assure that packages will almost certainly remain intact in aircraft accidents occurring during take-offs, landing, or ground operations. These types of accidents not only represent the majority of all aircraft accidents, but also are the kind most likely to occur in an urban area. The criteria will also afford a high degree of protection against accidents which occur in other phases of flight, including accidents of extreme severity such as mid-air collisions, high-speed crashes and fires. A two phase program to develop and test a high integrity package that meets the qualification criteria is in progress.

The qualification criteria, the package design, the test results and the supporting documentation are to be reviewed by the Advisory Committee on Reactor Safeguards and the Assembly of Engineering of the National Academy of Sciences, prior to NRC's certifying the design to the Joint Committee on Atomic Energy. In the fall of 1976, the ACRS endorsed the criteria devloped by the NRC staff as being properly responsive to Public Law 94-79. Both the review by the Assembly of Engineering and the certification procedures are expected to be completed in 1977.

Environmental Impact Statements

Air Transport of Nuclear Materials

Description: From its inception in January 1975, the NRC has reviewed the existing regulations and procedures for transportation of radioactive materials. As part of its review, the Commission initiated in June 1975 a public rulemaking proceeding regarding the air transport of all nuclear materials, including plutonium and enriched uranium.

With the technical assistance of Sandia Laboratories, a Draft Generic Environmental Impact Statement was prepared to assess the impacts associated with the transportation of radioactive materials, including relative costs and benefits of alternative modes.[47] Information derived from research into the accident-resistant properties of plutonium shipping packages, and data collected from the NRC's 1975 Radioactive Material Shipments Survey, were used in preparing the Statement. About 30 letters of comment were received and analyzed, and changes to the Statement will be made, as appropriate, before the Final Environmental Impact Statement is issued in 1977.

EPA/ORP Response and Status: EPA/ORP rated the Statement "environmentally unsatisfactory" because doses to individual passengers on aircraft were considered excessive. NRC indicated, without discussion, maximum and average individual dose rates as 340 mrem/year and 60 mrem/year, respectively. In its 1974 recommendations to the Federal Aviation Administration, EPA/ORP had recommended a seat level dose rate of 0.5 mrem/hour -- which in the worst assumed case resulted in 42-mrem/year -- and demonstrated a cost effective method to reach this level. It appeared that, in discarding the approach EPA/ORP recommended, NRC was not following the "as low as reasonably achievable" philosophy. The other major criticism of the Statement was that its accident analysis model was apparently based on incomplete test data.

Studies

Monitoring

During 1976, NRC initiated a long term State/Federal collaborative program to assess the current practices in the transportation of radioactive material under existing regulations. Under this program a State contracts with NRC to engage in a two year cooperative effort for the surveillance of radioactive materials in transport. The surveillance is conducted at designated locations in order to obtain information on the condition of packages, handling practices, and other pertinent data. An ancillary benefit to the States is the enhancement of their expertise in dealing with radioactive material shipments.

Survey of Radioactive Material Shipments

To determine the total number and types of packages of radioactive material being transported annually in the U.S., the NRC conducted a survey among some 2,300 NRC and Agreement State licensees and ERDA contractors. A detailed report of this survey (BNWL-1972) was issued in April 1976 by Battelle-Pacific Northwest Laboratories, and a summary report (NUREG-0073) was made available by NRC in May 1976.[48] Based on the survey data, the estimated total number of packages of radioactive material transported each year in the United States is about 2.5 million. About one-third of these packages contain such small quantities of radioactive materials that they are exempt from packaging and labeling requirements. The data from the survey were used in other studies to estimate radiation exposures from normal transport of radioactive material, and to calculate the risk to people and the environment from transportation accidents involving such packages.

Large Shipping Cask Safety

The development and verification of analytical procedures is necessary to predict with greater confidence the margins of safety which exist in the design of large, complex, and costly shipping containers such as spent fuel shipping casks. For these packages, physical testing of each individual design, ultimately involving their damage or destruction, is not necessary or justified. NRC, therefore, has ongoing research efforts to establish analytical methods for evaluating the structural and thermal performance, and shielding and sub-criticality features of these casks and their critical components. Identification of the physical tests required to verify the capability of the analytical model procedures has been initiated.

Transport in Urban Areas

The NRC has undertaken a study of the special features of radioactive material transport--under both normal and accident conditions--in large densely populated areas. It will result in a Generic Environmental Impact Statement on the transport of radionuclides in urban environs. The study will evaluate the effects, including radiological safety, of characteristics peculiar to large cities, such as high population density, local meteorology, and numerous tall buildings. Sandia Laboratories, the NRC contractor for this study, has begun model formulation and preliminary data gathering. The study will take about two years to complete.

To help in developing an assessment model, the contractor formed a Task Group composed of members from Federal, State and local agencies as well as industrial, academic and environmental public interest groups. The group met twice in 1976 and has scheduled its first draft assessment for July 1977.

• Accident Prevention

Guidance

Qualification Testing of Components

Reports from NRC inspectors in the field have indicated that some active components--particularly pumps and valves--have not functioned when called on in tests or during operation. The staff has encouraged the American National Standards Institute (ANSI) to initiate development of standards to provide greater assurance that components will operate when needed. As part of this effort, ANSI published a standard on functional specifications for nuclear valves, with the major focus on qualification testing.

Fire Protection

As a result of a fire in electrical cable trays in the Browns Ferry Nuclear Plant in Alabama, the NRC initiated a program to evaluate the need for improving fire protection in nuclear power plants. As part of this continuing evaluation, the NRC, in February 1976, published a report by a special review group, "Recommendations Related to Browns Ferry Fire" (NUREG-0050).[49] This report recommends that improvements in fire prevention and control should be made in most existing facilities, and that consideration should be given to increasing their ability to withstand large fires without the loss of important functions. In May 1976, the NRC's Office of Nuclear Reactor Regulation issued specific recommendations for fire protection programs and included them in the acceptance criteria of the licensing review for nuclear power plants.

Detailed guidelines for nuclear power plants were issued in June 1976,[50] describing how to implement NRC's requirement that the probability and effects of fire be minimized, and how to design fire safety features into nuclear power plants.

The NRC is reevaluating fire protection programs at all nuclear power stations.

Enforcement

Abnormal Occurrences

Under Section 208 of the Energy Reorganization Act of 1974, NRC is required to "...submit to the Congress each quarter a report listing for that period any abnormal occurrences at or associated with any facility which is licensed or otherwise regulated pursuant to the Atomic Energy Act of 1954, as amended, or pursuant to this Act. For the purposes of this section, an abnormal occurrence is an unscheduled incident or event which the Commission determines is significant from the standpoint of public health or safety...."

NRC has developed two major interim criteria, according to which abnormal occurrences are:

(1) events involving an actual loss of the protection provided for the health or safety of the public; and (2) events involving major reduction in the degree of protection provided.

Only one of the events occurring at an NRC licensed facility from July 1975 through June 1976 had any direct impact on or consequence to public health and safety. (This was the exposure of certain hospital patients to amounts of radiation in excess of those prescribed, at Riverside Methodist Hospital in Columbus, Ohio.) Of some 2,200 Licensee Event Reports received during this time, a total of three events at operating nuclear power plants were considered to have sufficient safety significance to be abnormal occurrences. For operating fuel cycle facilities other than reactor plants, there was one abnormal occurrence, and for other materials licensees--hospitals, radiographers, waste disposal contractors, etc.--there were six abnormal occurrences.

Deficiencies in Containment

Late in January of 1976, the NRC received the results of tests conducted by the General Electric Co. pertaining to boiling water reactors with the "Mark I" containment design. Potential problems with the design first came to light in April 1975, during safety reviews of the advanced Mark III containment by the reactor vendor.

Since the potential problem was identified, the NRC has: requested the additional information which led to the tests conducted by the vendor and owners' groups; closely reviewed the test results as they were developed; and required all appropriate licensees to increase the safety margin by altering their mode of operation.

All of the utilities involved, as well as the vendor, have undertaken continuing efforts to obtain the data needed to confirm design adequacy -- or to plan further actions to provide the safety margins intended in their original designs. NRC is following their long term programs to achieve this result and is conducting independent research to confirm the adequacy of existing safety margins.

Studies

Review of Plutonium Facilities

The NRC staff undertook this year the task of examining and evaluating plutonium fuel fabrication facilities to determine the effects of natural phenomena such as tornadoes and floods upon the public health and safety. The decision to review all facilities at one time was made to promote the highest degree of uniformity. The NRC staff, including expert consultants, is reviewing the selected facilities on a site-specific basis and will provide a safety assessment for each. These assessments will provide a basis for determining the extent of any changes necessary to protect each facility from the effects of natural phenomena.

Health and Environmental Research

NRC research to improve environmental measurement and monitoring technology is directed to continued refinement in the control of effluents from nuclear plants. While there is a great wealth of knowledge gained from past years of nuclear safety research, there is a continuing need to study important issues directed to current applications of nuclear energy. Some of the areas being investigated by NRC and ERDA are the potential health effects in large populations from long term exposure to low levels of radiation; the potential for interactions between radioactive and chemical effluents from the nuclear industry and environmental systems; the possible effects of nuclear plant effluents in the presence of other industrial pollutants in the environment; and the methodology for predicting and assessing potential environmental impacts.

Facility Safety Studies

During 1976, NRC started an extensive program to confirm and refine the effluent release models used by the licensing staff in their review of nuclear power plants. Measurements were carried out in two operating reactors which characterized the sources and concentrations of radioactive materials throughout the entire reactor plant. This in-plant measurement program will be extended to other operating reactors to provide a comprehensive review of actual radioactivity sources and releases under a variety of operating conditions.

In view of the growing need to provide for storage of spent reactor fuel, additional nuclear criticality studies have been undertaken to assure that spent fuel storage system designs will continue to provide adequate margins of safety.

Water Reactor Safety Tests

NRC conducted some water reactor safety tests at ERDA's Loss of Fluid Test Facility (LOFT), a 55 megawatt thermal pressurized water test reactor. The facility is designed to accommodate study of nuclear, thermal-hydraulic, and structural phenomena occurring during a postulated loss-of-coolant accident (LOCA).

The major objective of the LOFT test program is to provide data to evaluate and improve the analytical methods now used to predict the LOCA response of a large pressurized water reactor. Thus, LOFT has been designed to perform a number of experiments and provide measurements of system response. These measurements are compared with pretest predictions to check the capability of computer codes. The first non-nuclear test in LOFT was run on March 4, 1976, and the facility performed well. Computer code predictions compared well with LOFT data. Repeatability of the LOFT results was excellent, indicating that the plant and the data acquisition system perform in a consistent manner to assure the reliability of the data.

Fuel Behavior

The escape of radioactivity from nuclear power plants is prevented in part by barriers designed into the structural and operational features of the plants. One such barrier is the cladding around the nuclear fuel pellets. An important goal of NRC's reactor safety research is to improve the understanding of the response of fuel element pellets and cladding to a postulated nuclear accident. The research programs in this area involve laboratory studies and in-pile tests, i.e., experiments conducted in an operating nuclear reactor. These activities provide data for the development of analytical computer codes, which in turn are verified by comparing predictions with results of additional experiments.

Metallurgy and Metals

NRC-sponsored metallurgy and materials research is related to the integrity of the primary system pressure boundaries (vessels, components and piping) in light water reactors. These heavy-walled vessels, components and pipes must remain intact at all times, since failure could lead to a loss of coolant accident. The ability of the steel vessel, components and piping to retain integrity throughout operating and accident conditions is governed by (1) the material properties and the response of the steel to the reactor environment, and (2) the size and orientation of any flaws that may exist in the vessel, components or piping.

Site Safety Research

Potential effects on nuclear facilities of earthquakes, tornadoes, floods, and other natural phenomena are considered by NRC in the licensing process. Research in safety related aspects of siting focuses on the characteristics and distribution of severe natural phenomena in the U.S., and upon the engineering methods which are used to mitigate the effects. The information developed is used by the NRC in the evaluation of sites during the licensing process and to provide bases for improving siting guides and criteria.

Operational Safety

NRC has expanded its research into reactor operational safety matters — specifically, fire protection and qualification testing evaluation. The programs were initiated to evaluate the currently utilized standards and guides in these areas.

During fiscal year 1976, a fire protection research plan was written based on the general recommendations of NUREG-0050, "Recommendations Related to Browns Ferry Fire" and reflecting the specific needs of NRC user offices. Resulting research includes confirming the effectiveness of cable tray separation criteria, which prevent the spread of a fire between electrical cables of redundant safety systems.

The qualification testing evaluation research was started in fiscal year 1976, combining separate research programs already underway by NRC; it covers questions of aging and the evaluation of synergistic effects of combined radiation and steam environment testing.

NRC's Advanced Reactor Program

Two types of advanced reactors -- the liquid metal cooled fast breeder reactor (LMFBR), and the high-temperature gas-cooled reactor (HTGR) -- are the focus of this program. It aims at providing confirmatory data to assist in the licensing process on a schedule commensurate with ERDA's program for LMFBR commercialization. The gas-cooled program centers on generic issues of HTGR safety, pending the outcome of ERDA-industry development efforts.

Some of NRC's 1976 research on the LMFBR will help in reviewing ERDA's Clinch River Breeder Reactor, in the areas of severe accident analyses and radiological source assessments. The program is divided into several areas, including:

Analysis: Computer codes and mathematical models are created to predict how a plant would behave under a wide variety of extreme conditions. This effort, when properly verified by experiment, avoids the need for a repetitious series of costly and destructive tests. It is the backbone of the safety research effort.

Safety Test Facility Studies: The need for new facilities to conduct special reactor safety tests is studied to determine the facility specifications. These are transmitted to the ERDA for incorporation into their construction plans. Studies also consider special equipment needs and the details of the safety tests.

Material Interactions: In the course of an accident, materials such as fuel or cladding can be overheated and, when they come into contact with sodium or concrete, interact to produce vapors and new chemical compounds. The expanding vapors are a potential cause of damage. This program provides confirmatory data to assess that potential.

• Emergency Response Planning

Guidance

Basic Documents

The basic documents for the guidance of State and local governments in the development of their radiological emergency response plans are EPA's "Manual of Protective Action Guides and Protective Actions for Nuclear Incidents" (EPA 520/1-75-001) and NRC's "Guide and Checklist for Development and Evaluation of State and Local Government Radiological Emergency Response Plans in Support of Fixed Nuclear Facilities" (NUREG-75/111).[31]

EPA's Manual has been prepared to provide practical guidance to State, local, and other officials on criteria to use in planning for radiological emergencies that could present a hazard to the public. It provides a perspective for protective actions and guidance for planning and implementation of protective actions to protect the public in the event of a nuclear incident. The Manual calls for agreements that nuclear power facility operators will notify government representatives promptly of any significant accident. In that unlikely event, State and local officials would simultaneously:

— take the first protection actions, such as evacuation and/or instructions to the public to take cover and stay indoors,

— dispatch survey teams to make radiation measurements to help evaluate the size or location of the area requiring action,

— send emergency teams to restrict access to the affected areas.

One appendix to the Manual, which provides technical bases used for calculating projected doses from airborne releases, was drafted and circulated for review by States, industry, and Federal agencies during 1976. It will be issued in final form for incorporation into the Manual in 1977, along with another appendix, "Planner's Evaluation Guide," which was drafted under contract.

A study of the criteria in the "Guide and Checklist" was undertaken in early 1976 by eight Federal agencies. The views of the Conference of Radiation Control Program Directors, the National Association of State Directors for Disaster Preparedness, and the U.S. (local) Civil Defense Council were solicited. A principal result of the study will be a rating of the items in the "Guide and Checklist" according to whether they are considered essential or merely desirable. The goal of this effort is to help identify those emergency response plans which meet minimum criteria.

EPA/ORP Protective Action Guides

To ameliorate the consequences of a radiological incident EPA/ORP continued to develop Protective Action Guides (PAGs) and recommend appropriate protective actions to avoid or reduce exposure. Protective action must be taken when the projected absorbed dose to the population exceeds the PAG established. Different actions may be appropriate under various circumstances, depending on the nature of competing risks.

In the event of a nuclear incident, there may be a hazard to the population from airborne material and from contaminated food and property. In providing assistance, three accident phases are considered with separate PAGs for each:

1. emergency phase, when quick decisions and actions would be required to protect the public from whole body exposure and inhalation exposure,
2. intermediate phase, when whole body exposure would result mostly from deposited material and ingestion of contaminated food and water, and
3. long term or recovery phase, where low level direct radiation and contaminated food would be the critical exposure pathways.

Emergency Phase: EPA/ORP established a range of one to five rem projected whole body dose and five to 25 rem projected thyroid dose as PAGs, and began developing Guides for the lungs. In the lower end of the PAG range, easy and inexpensive protective action should be taken, while, in the higher end, PAGs require judgment in application under actual accident conditions. (These Guides were originally issued as EPA/ORP guidance only, but are being prepared for submission to the President and promulgation on an agency wide basis).

Once it has been determined that the projected dose in the emergency phase exceeds the applicable PAG, various actions can be taken, including evacuation, sheltering and controlled access to affected areas. Also, prophylaxis may be necessary to block the thyroid from radioiodine exposure, and the Food and Drug Administration is studying the appropriate dosage form for the device and its availability. Recommendations will be made in FY 78. Respiratory devices, including makeshift types, are also being considered to provide protection in emergencies.

Intermediate phase: PAGs were under development in 1976 and will be drafted in 1977. Various categories for the intermediate phase

TABLE 4.4

PROTECTIVE ACTION GUIDES FOR WHOLE BODY AND THYROID EXPOSURE TO AIRBORNE RADIOACTIVE MATERIALS

Population at Risk	Projected Whole Body Gamma Dose (rem)	Projected Thyroid Dose (rem)
Nonessential personnel	1 to 5(a)	5–25
Emergency workers	25	125
Lifesaving activities	75	(b)

(a)When ranges are shown, the lowest value should be used if there are no major local constraints in providing protection at that level, especially to sensitive populations. Local constraints may make lower values impractical to use, but in no case should the higher value be exceeded in determining the need for protective action.

(b)No specific upper limit is given for thyroid exposure since, in the extreme case, complete thyroid loss might be an acceptable penalty for a life saved. However, this should not be necessary if respirators and/or thyroid protection for rescue personnel are available as a result of adequate planning.

could include a preventive PAG for use when actions causing minimal social and economic impact would be justified, and emergency PAGs for situations when actions having high impact are justified because of projected health hazards.

Long term or recovery phase: PAGs were also being formulated for this phase; they will be based on cost/risk analyses resulting from studies currently underway.

NRC Handbook

In support of the interagency field effort in radiological emergency response planning assistance, the NRC Office of State Programs published in June a document entitled "Radiological Emergency Response Planning--Handbook for Federal Assistance to State and Local Governments," NUREG-0093/1.[32] This document sets forth guidelines for the activities of the eight Federal agencies involved.

Task Force on Offsite Emergency Instrumentation

The Federal Interagency Task Force on Offsite Emergency Instrumentation Systems, formed in 1974, continued in 1976 to provide guidance to State and local emergency response planning officials on offsite radiation detection systems and associated instrumentation. One project the Task Force is responsible for evaluating is directed at the development of a portable, field operated monitor which can measure elemental and organic forms of radioiodine in the presence of noble gases. The purported advantages of this system, due for completion sometime in FY 77, are the relatively short sampling time and low expense.

Also, early in 1976 the Task Force completed and submitted to the Federal Interagency Central Coordinating Committee a draft interim report, "Guidance on Offsite Emergency Radiation Measurement Systems, Phase I — Airborne Releases" which incorporated comments by the involved Federal agencies and the Conference of Radiation Control Program Directors. The final draft is expected to be ready for comment in 1977.

International Activities

During 1976 EPA and NRC participated in an International Atomic Energy Agency (IAEA) effort to develop international guidance on plans for response to major radiological accidents. This effort is continuing, and a draft report from IAEA should be available in 1978.

Studies

EPA/ORP Contracts

An EPA/ORP contract was completed during 1976 which evaluated the benefits of shelter and compared the relative benefits of shelter and evacuation. A contract on the study of the cost-effectiveness of control methodologies (protective actions) for exposure from contaminated property and equipment will be finalized in FY 78.

Education

Training Programs

The Federal agencies responsible for emergency response planning have identified a number of areas where training is needed for State and local government personnel. They have developed, or are currently developing, formal training courses for each of several areas.

A one-week course in radiological emergency response planning has been conducted 11 times since its inception in March of 1975. As of the end of fiscal year 1976, approximately 360 State and local government emergency planning personnel from 48 States have attended. Pilot courses in radiological monitoring and radiological emergency medical response, developed and conducted by ERDA contractors, were formally evaluated by a working group composed of Federal, State and local government emergency preparedness personnel. These evaluations were used in developing revised curricula. Because of limited Federal funding for these courses for State and local government personnel, only a modest start was made in offering them in 1976.

State/Federal Programs

GAO Report

In March the General Accounting Office (GAO) audited NRC's activities in emergency response planning and issued a report, "Stronger Federal Assistance to States Needed for Radiation Emergency Response Planning." It made two specific recommendations to NRC in its "lead agency" role.[53] The first was that NRC report periodically to the Congress on the status of Federal efforts to help the States in their planning, setting out: (1) State actions to improve their plans; (2) the relationships and commitments of the various Federal agencies involved; (3) any recommendations for legislation which would enable NRC to increase its help to States in preparing adequate plans. NRC indicated that it would comply with the recommendation by including, in future annual reports to the Congress, a more comprehensive section on the status of the effort to assist States in their planning.

The second GAO recommendation to NRC was that the Office of State Programs have representatives at the NRC regional offices to provide better liaison with State and local governments. NRC indicated its intent to comply with this recommendation as funding allowed. A study on increased regionalization of NRC activities, including assistance to State and local governments in emergency response planning, was near completion at year-end.

In addition to making specific recommendations, the GAO report presented several conclusions. One was that State plans for dealing with radiation emergencies need improvement, notwithstanding NRC's progress in support of this effort. The report also concluded that "the success of Federal efforts to improve State radiation emergency plans now depends substantially on how committed the States are to developing adequate plans."

Shift to Regions

During 1976 the responsibility for assisting States in the development of their radiological emergency response plans was shifted from Washington headquarters to the regions. Each responsible Federal agency appointed a member to each of ten regional committees, all of whom are providing technical support in developing State emergency plans and evaluating emergency exercises. In addition, a headquarters committee was formed to offer general coordination, policy guidance, and technical assistance to the regions when necessary. Committee activities in 1976 included:

— providing eight States with assistance in developing plans,

— initiating of twelve State plans, with updating action planned as new information becomes available, and

— critiquing six simulated tests of State plans.

NRC/EPA Task Force

An NRC/EPA Task Force on Emergency Planning was appointed in 1976 to determine the types of radiological accidents that States and local governments should plan for and develop preparedness plans to support. Among the concerns to be addressed is the apparent disparity between the NRC "Guide and Checklist" recommendations and the *Reactor Safety Study's* estimate of the risks of extremely severe accidents.

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Below are publication numbers for relevant items cited in Appendix B. Most ERDA and NRC publications will be helpful, so they are not listed separately below; see the full information in the Appendix.

EPA Technical Reports:

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520/5–76–005
520/3–76–009
520/3–76–011
520/5–76–015
520/4–76–016B
520/4–76–017
520/5–76–020

EPA Authored Reports: See Brinck, Blanchard, Gruhlke, Holcomb, Meyer, Phillips, Richardson, Rowe, and Russell.

EPA Technical Notes:

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ORP/CSD 76–2
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ORP/EAD 76–4
ORP/LV 76–1
ORP/LV 76–2
ORP/LV 76–3
ORP/LV 76–5
ORP/LV 76–9
ORP/TAD 76–3
ORP/RAD 76–4

OTHER NUCLEAR SOURCES

• Nuclear Weapons Testing

The Treaty on the Limitation of Underground Nuclear Weapon Tests, commonly known as the Threshold Test Ban Treaty, and its companion Treaty on Underground Nuclear Explosions for Peaceful Purposes have been signed and introduced to the U.S. Senate for ratification. These treaties limit individual underground nuclear tests to 150 KT. In the interim, pending their entry into force, the United States has announced its intention to abide by the yield limits of the treaties. However, the capability to conduct larger nuclear tests at the Nevada Test Site (NTS) remains unchanged.

Since the 1963 Limited Test Ban Treaty, ERDA and its predecessor (the Atomic Energy Commission) have conducted underground nuclear tests to support (1) national laboratories' development of weapons in response to Department of Defense requirements, and, in previous years, (2) ERDA's development of explosives for peaceful applications.

Each test is reviewed in advance by a Containment Evaluation Panel of experts drawn from the Los Alamos Scientific Laboratory, the Department of Defense, the U.S. Geological Survey, the Sandia Laboratories, and the Lawrence Livermore Laboratory. The Panel considers many factors which could contribute to atmospheric discharges, such as device yield, hydrology, closure methods, and drilling and construction histories.

During the test itself and on the day before the test, a Test Controller's Advisory Panel is convened to advise on possible effects. Mobile monitors are sent to areas downwind of the detonation to monitor possible releases, and aerial surveillance is conducted above the site itself to track any radioactive clouds.

Announced U.S. nuclear detonations during 1976 are shown in Table 5.1.

People's Republic of China Nuclear Detonations

On September 26, 1976, the People's Republic of China detonated a nuclear device with an estimated yield of 20,000-200,000 tons of TNT equivalent, at the Lop Nor test site in southwest China. A second atmospheric detonation followed on November 17, with a yield of about four million tons of TNT equivalent. Since the tests were above ground, large amounts of radioactive materials were swept through the atmosphere. They crossed the U.S. several days after each test.

Before the contaminated air mass from the first detonation reached the U.S., EPA's Office of Radiation Programs (EPA/ORP) activated 46 additional standby air particulate and precipitation sampling stations, as well as increasing sampling frequencies for the 21 air sampling stations normally operated. They are part of the Environmental Radiation Ambient Monitoring System (ERAMS). The air particulate samples were used to estimate the potential inhalation dose to the U.S. population, and precipitation samples were collected to indicate rainout of radioactive materials. Since the most critical exposure pathway for the movement of iodine-131 and strontium-89 in fallout contamination was from pasture grass to ingestion by cows, particular emphasis was placed on sampling pasteurized milk. Iodine is of special concern because it concentrates in human thyroids.

EPA/ORP's special monitoring of the concentrations of radioactivity in air particulates, precipitation, and milk continued until the concentrations returned to normal in early November. The EPA/ORP program included the collection of 293 pasteurized milk samples, 1124 air particulate samples, and 39 precipitation samples. As a result, over 1600 radiation measurements were made at EPA's Eastern Environmental Radiation Facility in Montgomery, Alabama. Following the November 17 detonation, the standby portion of the ERAMS air particulate and precipitation network was again activated and special milk sam-

Table 5.1

Announced United States Nuclear Detonations

Event Name	Date (CGT)	Purpose	Yield Range
Tybo	5/14/75	Weapons Related	200 to 1000kt
Stilton	6/3/75	Weapons Related	20 to 200kt
Mizzen	6/3/75	Weapons Related	20 to 200kt
Mast	6/19/75	Weapons Related	200 to 1000kt
Camembert	6/26/75	Weapons Related	200 to 1000kt
Marsh	9/6/75	Weapons Related	Less than 20kt
Husky Pup Dod Event	10/24/75	Weapons Effects	Less than 20kt
Kasseri	10/28/75	Weapons Related	200 to 1000kt
Inlet	11/20/75	Weapons Related	200 to 1000kt
Leyden	11/26/75	Weapons Related	Less than 20kt
Chiberta	12/20/75	Weapons Related	20 to 200kt
Muenster	1/3/76	Weapons Related	200 to 1000kt
Keelson	2/4/76	Weapons Related	20 to 200kt
Esrom	2/4/76	Weapons Related	20 to 200kt
Fontina	2/12/76	Weapons Related	200 to 1000kt
Cheshire	2/14/76	Weapons Related	200 to 500kt
Estuary	3/9/76	Weapons Related	200 to 500kt
Colby	3/14/76	Weapons Related	500 to 1000kt
Pool	3/17/76	Weapons Related	200 to 500kt
Strait	3/17/76	Weapons Related	200 to 500kt
Mighty Epic Dod Event	5/12/76	Weapons Effects	Less than 20kt
Billet	7/27/76	Weapons Related	20 to 150kt
Banon	8/26/76	Joint US-UK	20 to 150kt
Chevre	11/23/76	Weapons Related	Less than 20kt
Redmud	12/8/76	Weapons Related	Less than 20kt
Asiago	12/21/76	Weapons Related	Less than 20kt
Rudder	12/28/76	Weapons Related	20 to 150kt

ples were collected, until it was apparent that no fallout from this detonation could be detected.

From the ERAMS data collected from September to December, EPA/ORP concluded that potential health effects from fallout caused by the Chinese tests are minimal. Air particulate data indicated that most measurements were within the range of normal background fluctuations, and that no significant increase in population exposures could be estimated for the inhalation pathway. (Data are available on request; see Appendix on 1976 publications.)

Most of the milk data indicated normal background or slightly elevated levels of radiation, although some samples in the eastern U.S. did have higher levels. Potential effects from iodine-131 in milk were estimated, using the highest reported level in each State as the representative value for all milk produced in that State; results indicated that a maximum of 4.3 potential excess thyroid cancers could occur as a result of the September test. It will not be possible to identify any of these excess cases over the next 45 years when they are expected, because 380,000 cases are anticipated in the U.S. as the normal incidence from other causes. Health effects were also estimated for strontium-89 from milk ingestion. This isotope concentrates in human bones and may lead to an estimated 0.005 to 0.02 excess leukemia deaths in the U.S.

Because the estimates for both iodine and strontium exposures are based on conservative assumptions, they overstate the probable true impact of the Chinese tests. Thus, the detonations' fallout contamination of milk should not result in significant health effects for the U.S. population. The public was kept informed of EPA/ORP's monitoring and sampling activities during the fall by frequent press releases. A comprehensive report detailing EPA/ORP's evaluation of fallout from the Chinese tests will be published in 1977.

Because seven different Federal agencies were involved in assessing the impact of the tests, a formalized Memorandum of Understanding is being prepared to delineate the responsibilities of each and their interaction. EPA will coordinate the draft, which is being put together by FDA, ERDA, NRC, the National Oceanic and Atmospheric Administration, the Federal Aviation Agency, and the Air Force.

• United States Nuclear Navy

At of the end of 1975, the Navy was operating 106 nuclear submarines and seven nuclear-powered surface ships. Support facilities involved in construction, maintenance, overhaul and refueling of these vessels include nine shipyards, twelve tenders, and two submarine bases.

Within 12 miles of shore, less than 0.002 curies of long-lived gamma radioactivity were released annually by the nuclear Navy for the five-year period ending with 1975. (This figure includes all nuclear-powered ships and the ports they visited, as well as supporting facilities.) Most tritium released was beyond 12 miles from shore, a total of less than 200 curies. Not including tritium, the radioactivity released at sea was about 0.4 curies in 1975. Solid radioactive wastes from the Navy are packaged and shipped to licensed burial sites in compliance with NRC and Department of Transportation standards. In 1975, about 58,000 cubic feet and about 63 curies were disposed of.

The Navy concluded in their annual environmental report that radioactivity associated with their nuclear program has had no significant or discernible effect on the quality of the environment.[1]

• Radioisotope Applications

Radioactive materials are widely used for medical diagnosis and treatment, basic and applied research, teaching, consumer products, and industrial applications. These activities are conducted under approximately 19,000 nuclear material licenses, over half of which are administered by 25 States under regulatory agreements with the NRC. The 8,600 licenses administered directly by NRC include approximately 2,800 for medical use, 700 issued to academic institutions for teaching and research, and over 4,000 for industrial applications. The NRC processes 6,000-8,000 new applications and license amendments and renewals annually. Each application is given a thorough review to assure that the proposed use of radioactive materials will not endanger the public health and safety.

Among the 1976 licenses is one authorizing testing of a new system for detecting and giving an in-flight indication of incipient helicopter rotor failure. Using a small amount of radioactive material sealed in a metal capsule, the new system will signal the loss of rotor blade internal pressure in smaller helicopters. There is no in-flight warning system now, so lower than optimum speeds must be used to reduce the probability of failure without warning. The new system will be less costly than electromechanical, in-flight systems presently used on larger helicopters.

• Consumer Products

Guidance

NRC drafted a Regulatory Guide directed to petitioners for exemptions from NRC requirements for products containing radionuclides. The Guide, issued in June 1976,[2] is designed to assist in preparation of a required environmental report to support the petition. NRC evaluates the report and information from other sources, as well as preparing an environmental impact statement, prior to its final decision on whether an exemption will be allowed.

Environmental Impact Statements

In October 1975, the NRC issued its first Draft Environmental Impact Statement for a consumer product. It concerned a proposed rule to exempt spark-gap irradiators containing cobalt-60 for use in spark-ignited fuel oil burners. Placement of the irradiator near the spark gap eliminates the spark delay that is considered to be a contributory factor in some explosions in oil burning equipment. The Final Environmental Statement was being prepared at the end of fiscal year 1976.

Radiation Incidents Registry

FDA's Bureau of Radiological Health (BRH) continued to maintain its Radiation Incidents Registry, which tabulates the biological effects on humans which are reported to be associated with electronic product radiation. 1976 figures are presented in Table 5.2. The Registry has been useful in a number of ways: helping to determine the size and extent of the problem, how and why certain injuries occur, and the effectiveness of radiation control measures. Most important, Registry case reports can identify groups to follow in epidemiological surveys.

However, the Registry cannot provide estimates or statistical projections of future injury trends, nor can it be used to estimate trends, since reporting is voluntary and is known to vary from year to year.

Licenses

NRC has issued several licenses authorizing the use of small amounts of the radioactive gas tritium sealed in glass tubes to illuminate watches. These self luminous light sources are used in conjunction with a liquid crystal display (LCD) in watches with a digital display. The most common digital watch uses light-emitting diodes (LED) and an electric power cell; self-luminous lights and LCD make the cell unnecessary. In addition, the watch can be read at any time without the need to operate a switch as is necessary with battery-powered LEDs.

• Nuclear Powered Pacemakers

NRC published the "Final Generic Environmental Statement on the Routine Use of Plutonium-Powered Cardiac Pacemakers," NUREG-0060, in July 1976.[3] The Commission found that, based on a balancing of the benefits and risks involved, plutonium-powered pacemakers can be licensed for routine use. Previously, NRC had licensed them only on a limited, investigational basis.

The Statement concludes that the pacemakers have sufficient longevity to eliminate the need for surgical replacement operations which are required by pacemakers powered by chemical batteries. Also, plutonium-powered units can provide long term maintenance free pacing to patients for whom rechargeable pacemakers are either physically or psychologically unacceptable. Plutonium batteries can accommodate new or additional pacemaker functions that require high power drains without shortening their lives significantly.

EPA/ORP Response and Status: EPA/ORP commented on the lack of lung dose equivalents in the Statement and their potential importance, but expressed no other objections.

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2. "Preparation of an Environmental Report to Support a Rule Making Petition Seeking an Exemption for a Radionuclide-Containing Product." NRC: Regulatory Guide 6.7 (Rev. 1) (June 1976).

3. "Final Generic Environmental Statement on the Routine Use of Plutonium-Powered Cardiac Pacemakers." NRC: NUREG-0060 (July 1976).

PROTECTION FROM NONIONIZING RADIATION

1. Introduction and Summary

Although environmental levels of nonionizing radiation were negligible before the 1930's, virtually every American is now exposed. Sources have proliferated in number as well as power; in the ranges of primary interest, the radiofrequency (10 MHz to 300 MHz) and microwave (300 MHz to 300 GHz) frequencies, the environmentally significant sources include:

- radio and television broadcast stations
- radars
- satellite communications system earth terminals
- point to point microwave communications
- mobile communications systems
- microwave ovens
- industrial heating equipment.

Other nonionizing radiation sources are lasers that produce radiation ranging in frequency from the ultraviolet through the far infrared and overhead extra-high voltage power lines.

Quantum energies associated with microwave radiation at its extreme of 300 GHz are about 8000 times less than is needed to destroy cells by ionization; however, radiofrequency and microwave radiation do get absorbed by tissue and do interact with biological systems. The electromagnetic energy is transformed into increased kinetic energy of the absorbing molecules, and results in tissue heating. The process of absorption and distribution in irradiated tissue depends on the radiation wavelength and its relationship to the physical shape, size and distribution of a nonuniform system of tissues, the electrical characteristics of tissue at specific frequencies, and the intensity of the radiation.[1-2] A complex tissue structure such as the human body absorbs energy differently in specific parts, so that localized heating or nonuniform absorption may result.

Two kinds of effects on humans due to exposure to radiofrequency and microwave frequency radiation are usually discussed: thermal effects from high-level exposures, and possible low-level or "nonthermal" effects.

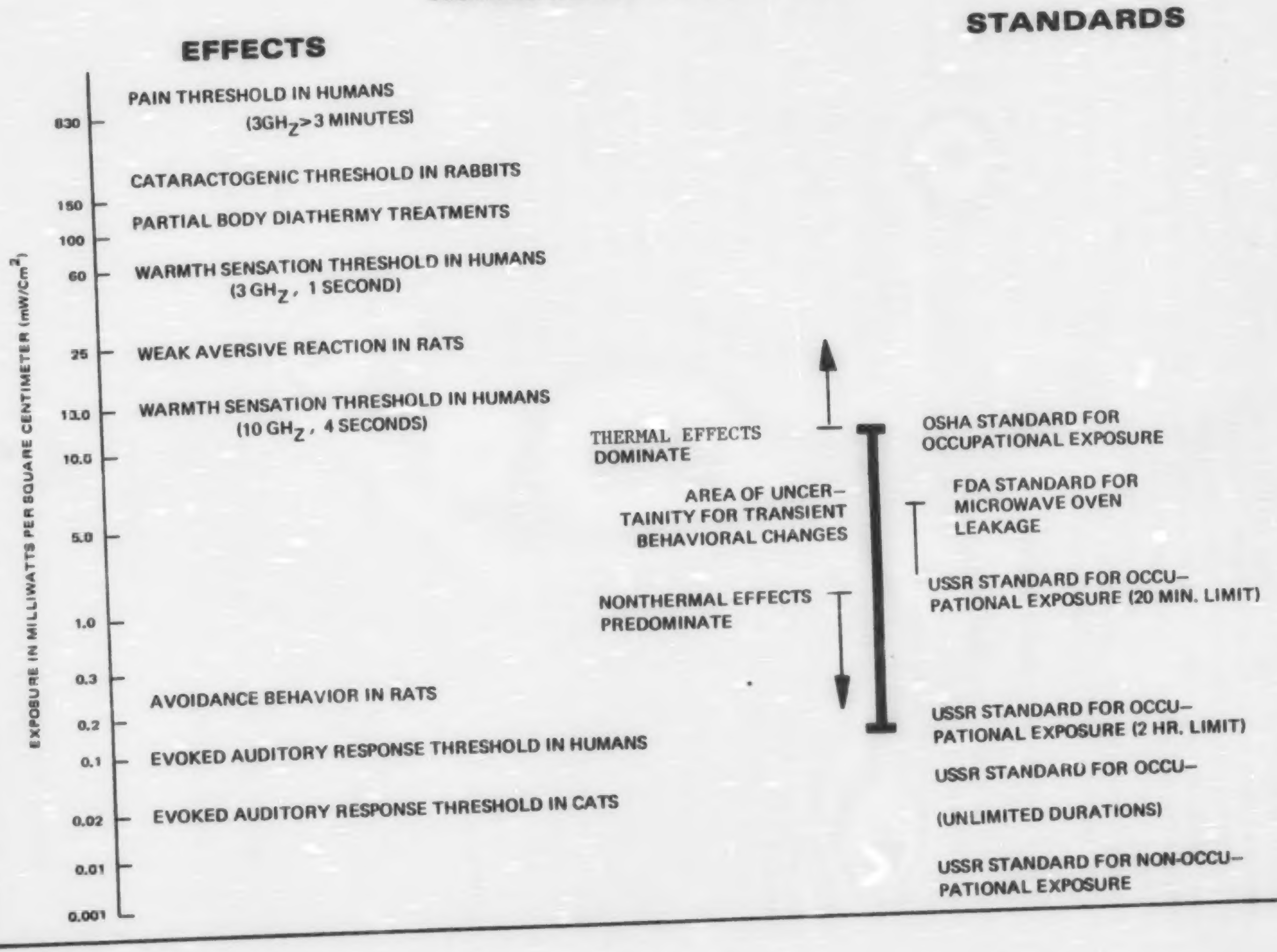
Thermal effects, resulting from irradiation with power densities above 10,000 microwatts/square centimeter (abbreviated as $\mu W/cm^2$, and equivalent to ten milliwatts/cm^2 or mW/cm^2), involve tissue heating with the possibility of thermal damage. They may include increased body temperature and resulting heat stress, cataract formation, cardiovascular effects, testicular effects, and brainwave pattern changes.[3]

Low-level effects are a subject of controversy. Effects of exposure to 1,000 $\mu W/cm^2$ (one mW/cm^2) or less have not been well documented; in fact, all U.S. scientists do not even agree that they exist. Some Russian and Czech scientists believe that they occur, but not as a result of increased tissue temperature (hence "nonthermal" effects). Their views are based on animal research and statistical studies of workers' exposure histories and medical records. Considered to be mainly central nervous system effects, symptoms attributed to low-level exposure include headache, weariness, dizziness, irritability, emotional instability, partial loss of memory, loss of appetite, cardiovascular effects, electroencephalogram changes, blood chemistry changes, changes in respiration, and possible genetic effects.[4]

While American scientists are skeptical of behavioral data and the conclusions of the Eastern European experts, there has been little research conducted in the U.S. involving long term exposures to low-level microwave and radiofrequency radiation intensities, even in animal experimentation. Some U.S. scientists believe that the effects observed, if real, could result from non-uniform energy distributions and very small localized temperature changes in the body, where the structure of certain molecular systems may be changed in some minor, reversible way.

TABLE 6.1

NONIONIZING RADIATION



The exposure limits in protective standards differ widely among various countries. In Eastern Europe, they are geared to protect against "non-thermal effects" of long term exposure to low intensity radiation. On the other hand, in the U.S. and most Western European countries, standards were designed with high level exposures and possible thermal effects in mind. Below are summarized both occupational and environmental exposure limits for the USSR, Czechoslovakia, Poland and the U.S. in simplified form.

The occupational exposure standards of the world generally fall into three groups on the basis of their exposure limits. The most conservative group includes the USSR and Czechoslovakia, with limits in the range of tens of μW/cm^2. In the middle group are the standards of Poland, Sweden, the Bell Telephone Company, and the N.V. Phillips Company (Netherlands), with limits in the range of hundreds of μW/cm^2 up to about 1000 μW/cm^2. The U.S. and most of Western Europe have standards in the most permissive group.

In the U.S. the principal occupational standard is the American National Standards Institute's (ANSI), which was reaffirmed with minor changes in 1974. The Defense Department has had a similar standard since about 1953; the Air Force recently adopted a value of 50 mW/cm^2, or 50,000 W/cm^2, for frequencies between one kHz and ten MHz, where previously there had been no standards. In 1971 the Occupational Safety and Health Administration adopted the 1966 version of the ANSI standard as a national consensus standard.[5] It recommends allowable limits of 10,000 μW/cm^2 for periods of 0.1 hours or more for frequencies from ten MHz to 100 GHz, with more intense exposures being allowed for shorter time periods. According to a December 31, 1975 decision, the OSHA standard is considered to be advisory rather than mandatory. In contrast, the USSR occupational exposures allowed for the 300 MHz – 300 GHz frequency range cannot exceed 10 μW/cm^2 for the duration of a working day, although greater exposures are allowed for short periods of time.

There are no general public health or environmental standards for microwaves in the U.S. (Other countries have typically set such levels about a factor of ten more restrictive than their occupational standards.) However, the U.S. does have a microwave oven performance standard, which limits the permissible microwave radiation leakage from the device itself, rather than the maximum level to which an individual might be exposed. The limit for new ovens is 1000 μW/cm^2, measured at any point five centimeters from the surface of the oven. Ovens in service may degrade to levels no greater than 5000 μW/cm^2 at the same distance. Although not directly comparable to the exposure standard, the microwave oven limits should probably be considered with the most restrictive group.

NONIONIZING·RADIATION STANDARDS (SIMPLIFIED)

Occupational Exposure (μW/cm^2)

	USSR	Czech.	Poland	US ANSI (advisory)
Above 300 MHz	10	25	200	10,000
30 - 300 MHz	6	25	106	10,000

Environmental Exposure (μW/cm^2)

	USSR	Czech.	Poland	U.S.
Above 300 MHz	1	2.5	10	(none)
30 - 300 MHz	1	.25	13	(none)

Although there were no major Congressional or judicial activities pertaining to nonionizing radiation in 1976, the Executive branch covered many sources and addressed them in diverse ways. While only EPA's Office of Radiation Programs (EPA/ORP) and FDA's Bureau of Radiological Health (BRH) activities are discussed in detail here, some other agencies — especially the Department of Defense, NASA and ERDA — are also involved in research efforts. Comprehensive activities included measurements of intentional microwave radiation at the Moscow U.S. Embassy, and interagency programs on the biological effects of radiofrequency and microwaves. In specific areas:

— BRH began the process of generating a draft performance standard for microwave diathermy applicators, and several major compliance actions were taken. EPA studies relating to microwaves and radiofrequency included urban area ,environmental measurements, measurements of RF levels in buildings, source distribution analysis for both RF and microwaves, and population exposure studies, as well as work on biological effects. BRH studies included here are on marine radar exposure, theoretical dosimetry, and a miniature microwave field probe.

— EPA/ORP prepared to let a contract to evaluate and summarize 6,000 pages of comments in response to its request for information on health and environmental effects of extra-high voltage power transmission lines.

— The Federal laser performance standard went into effect on August 2, 1976, preceded by two BRH documents explaining the standard to manufacturers. Compliance actions were undertaken when it became effective. In addition, BRH sponsored a public meeting to consolidate information on laser bioeffects and consider possible implications for Federal policy.

— After reissuing its warning against the hazards of broken mercury vapor discharge lamps, BRH issued a proposal recommending radiation safety performance criteria for them. Various research was conducted on light products and devices generally, such as light source measurements and development of a guide number for ultraviolet radiation.

2. Major Congressional and Judicial Activities

There were no major Congressional or judicial activities in this area in 1976. People concerned about nonionizing radiation may be interested in appropriations hearings for EPA and BRH, which are the main agencies dealing with it.

3. Executive Activities Pertaining to Public Exposure

• Comprehensive

Measurements at Moscow Embassy

Much press coverage was given to the intentional microwave radiation of the U.S. Embassy in Moscow by the Soviet Union. The maximum intensity there was reported to be 18 microwatts per square centimeter. Although there was much conjecture and speculation in the press on the subject, no health effects were linked to microwave exposure at the Embassy. EPA confirmed this information with the State Department at a 1976 meeting on the matter.

Interagency Programs on Biological Effects of Radiofrequency Microwaves

The Office of Telecommunications Policy (OTP) coordinates and oversees research and other Federal activities concerning bioeffects from the RF range generated by telecommunications. To assess bioeffects and develop a sound scientific basis for Federal action, OTP tracks individually funded activities by such agencies as EPA, HEW, the Department of Defense, and the National Bureau of Standards. OTP's statutory responsibility for spectrum management involves the review, management, and assignment of frequencies for Government use; the Office also advises the President on national telecommunications policy, and therefore is concerned with any possible adverse side effects which might be associated with the use of the spectrum.

Each year OTP issues a report on the Federal Government's program to assess biological effects of nonionizing electromagnetic radiation,[*] which covers environmental measurements, testing and research. These annual reports summarize research efforts, give short descriptions of participating agencies' programs and associated publications, and discuss related issues and problems. (The fifth annual report covering calendar year 1976 is being prepared and will be available in 1977.)

An Interagency "Side Effects" Working Group was established within the Technical Subcommittee of the Interdepartment Radio Advisory Committee. It helps to coordinate research and measurements programs as well as providing a useful forum for the exchange of information by 20 or so agencies that are represented.

• Radiofrequency and Microwave

Guidance

BRH met with researchers and clinical users to explore the clinical implications of a draft performance standard for microwave diathermy applicators.

Compliance

General Electric agreed to make repairs to assure that 36,000 home cooking ovens manufactured since November 1973 are in compliance with Federal standards. BRH found that the company's quality control and testing program was inadequate to assure that emissions criteria would be met.

In 1976, one compliance action was taken after the manufacturer itself reported noncompliance. Other BRH activities included:

— laboratory testing of 85 production or preproduction ovens, all found to be in compliance;

— inspection of 2,605 certified and 551 uncertified ovens;

— review and processing of survey forms for 441 certified and 164 uncertified ovens tested by the Air Force;

— review of records of 23 dealers or distributors to see whether they were sufficient to permit tracing of specific ovens to specific purchasers.

EPA Studies

Urban Environmental Measurements

As part of its program to determine the need for standards to control environmental nonionizing radiation exposure, EPA/ORP began measuring urban area environmental radiofrequency (RF) and microwave radiation levels in Boston and Atlanta in 1975. The study continued in 1976 with the completion of measurements in Miami, Philadelphia, New York, Chicago, and Washington, D.C.

Using a mobile computer controlled instrumentation system installed in a van equipped with electrical power generators (Figure 6.2), the measurements are made in the broadcast radiation frequency bands which are principally responsible for urban area exposure levels. Although data analysis through the end of 1976 included only the 72 sites located in Boston, Atlanta, Miami and Philadelphia,[9] measurements have been made at a total of about 200 locations for all of the cities included in the study to date. The combined results of the measurements of radiofrequency and microwave power densities for the 72 sites analyzed are presented in Figure 6.3. (The percentage of sites at which power densities exist with values equal to or less than a given total power density in the frequency range from 54 to 900 MHz is plotted as a function of log power density.)

The FM band contributes the most to environmental RF exposure between 54 and 900 MHz: each of the three TV bands contributes about equally, the land mobile band element is almost negligible, and less active bands are even less significant. The maximum power density at any of the 72 sites summed over all bands was 2.5 $\mu W/cm^2$. Four sites, or about six percent, fell in the range of one to 2.5 $\mu W/cm^2$, so that some of the population is potentially exposed to values in excess of one $\mu W/cm^2$, with a median exposure value of about 0.03 $\mu W/cm^2$. The maximum value measured to date at any of the 200 sites in any of the seven cities is about ten $\mu W/cm^2$.

Population Exposure to Radiofrequency

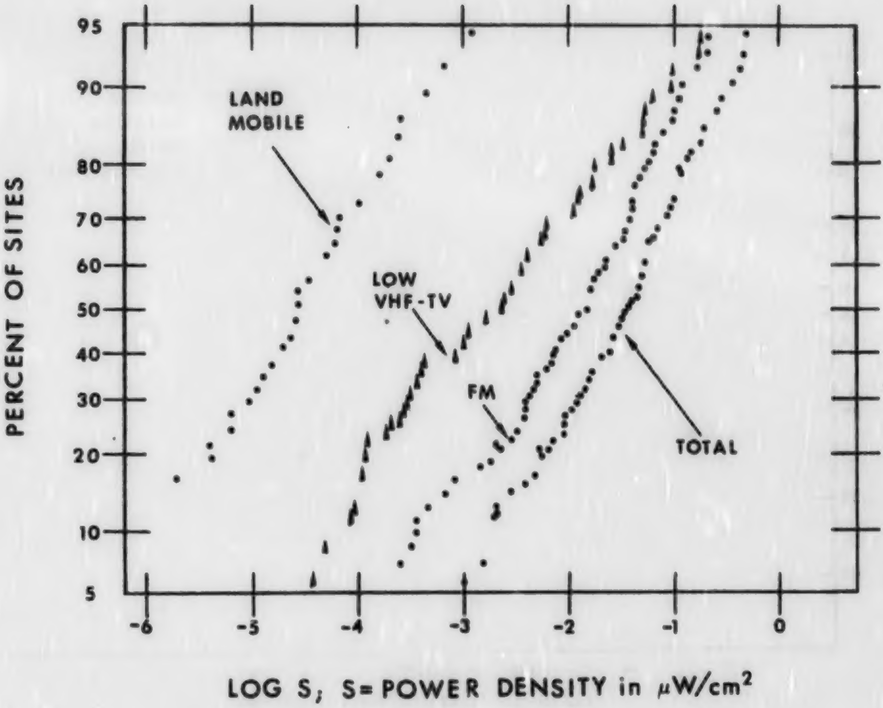
EPA/ORP estimated the population exposed to various radiofrequency levels for some of the urban areas studied. The total power density from all sources was determined at each of the discrete points where population is considered to be concentrated, and the number exposed at different levels was summed. Figure 6.4 shows the fraction of the population in metropolitan areas of Boston, Atlanta, Miami, and Philadelphia (total population = 8.3 million) estimated to be exposed to various levels of power densities. The median power density (based on population exposure) is 0.014 $\mu W/cm^2$. Less than one percent of the population is exposed to values greater than one $\mu W/cm^2$. (This estimate does not take into account exposure due to AM broadcast sources, daily movements of the population within an area, exposures at heights other than six meters above ground, attenuation effects of buildings, or times when sources are not transmitting.)

Measurements of Radiofrequency Levels in Buildings

To supplement data collected near ground level, EPA/ORP measured radiation levels on the upper floors of several buildings near broadcast transmitters in three cities. An example of a tall building located near a transmitter is shown in Figure 6.5. The office building on the left is a number of stories taller than the building on the right, which has a powerful FM radio transmitter mounted on its roof. Therefore, the upper floors of the building on the left are being exposed to the main beam of the FM transmitter. In such measurements, power density levels were shown to be greater than those commonly found near ground level.

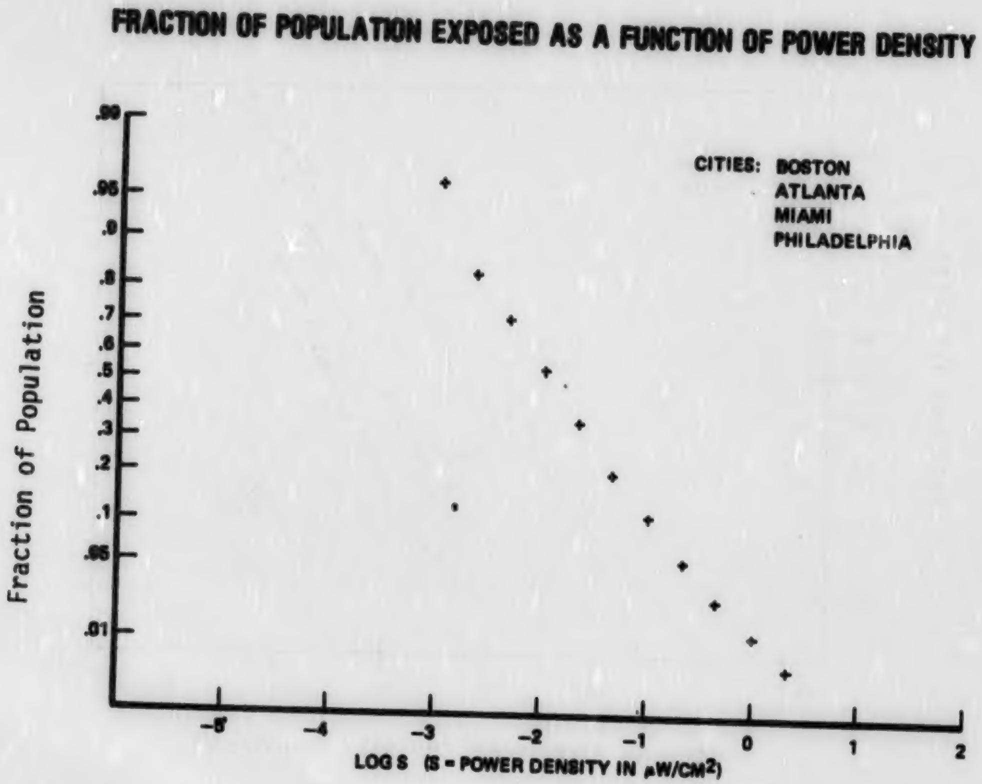
The maximum total power densities measured on the upper floors of selected buildings in New York, Miami, and Chicago were 32 $\mu W/cm^2$, 97 $\mu W/cm^2$, and 66 $\mu W/cm^2$ respectively, and consisted primarily of radiation from FM radio and UHF-TV transmitters.

Figure 6.2
Electromagnetic Radiation Analysis Van

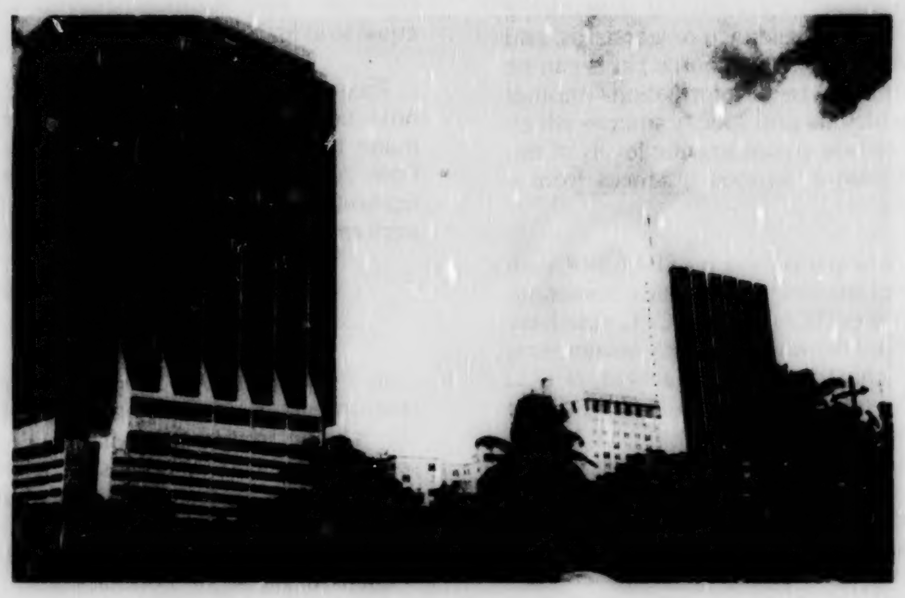


Integral Power Density Distribution

Figure 6.3



Fraction of Population Exposed at Various
Power Densities
Figure 6.4



Tall Building Exposure Situation
Figure 6.5

Radiofrequency and Microwave Source Distribution Analysis

EPA performed an analytic study[10] to obtain statistics on the distribution of RF and microwave sources, to evaluate their value for determining the impact of Federal guidance or standards, and to see whether existing data source bases can be used to obtain this type of information. Another objective is to identify and specify sources which can produce certain environmental levels of nonionizing radiation at various distances from a source antenna.

The study was performed by EPA/ORP with the assistance of the Electromagnetic Compatibility Analysis Center (ECAC). The ECAC data base is a computerized file with frequency assignments and pertinent characteristics for almost all U.S. sources of RF and microwave radiation (except for equipment operating in the amateur bands, citizen bands, land mobile bands, and aircraft and commercial maritime bands). ECAC provided the data base, computer software, data processing and sorting, and graphic results, while EPA defined the task, source selection criteria, calculational models, format for presentation of results, and is evaluating the results of the study.

The source categories included in the study are satellite communications earth terminals (SATCOMS), radars, and all continuous wave (CW) communications systems except broadcast transmitters, which are included in a separate study. As sources from the data base were selected on the basis of certain frequency assignments, on-axis time average power densities were calculated at a number of specified distances using EPA/ORP's analytical models. The results are organized for each system category and displayed as a series of histograms for each category.

Examples of the histograms illustrate the kinds of results obtained in the study. Figure 6.6 shows the number of frequency assignments for all systems which can produce an on-axis time averaged power density of at least ten W/m^2 (1000 μW/cm^2) at the indicated distances from the antennas. Figure 6.7 shows the number of frequency assignments in all categories which can produce power densities in the range of 1.0 to 10.0 W/m^2 (100 to 1000 μW/cm^2). Figure 6.8 shows the number of frequency assignments at a distance of 500 meters which have the capability to produce power densities equal to at least the values shown.

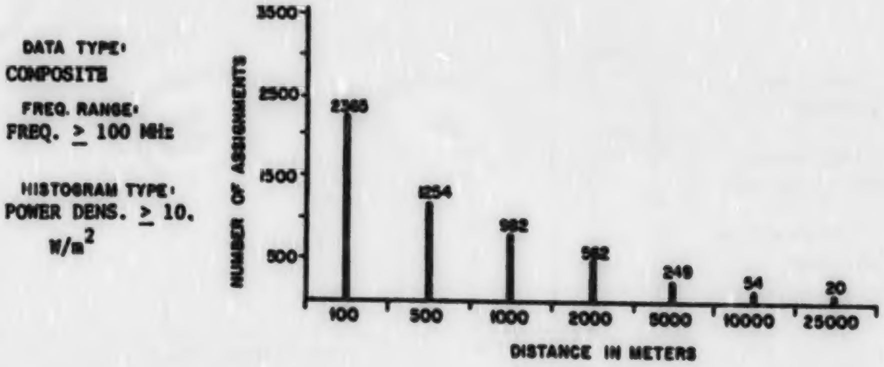
Frequency distributions in the initial study are now being corrected, and an attempt will be made to reduce the results to system distributions. After system errors are identified and modifications made, a second generation study will be performed.

Microwave Oven Electric Field Intensity Measurements

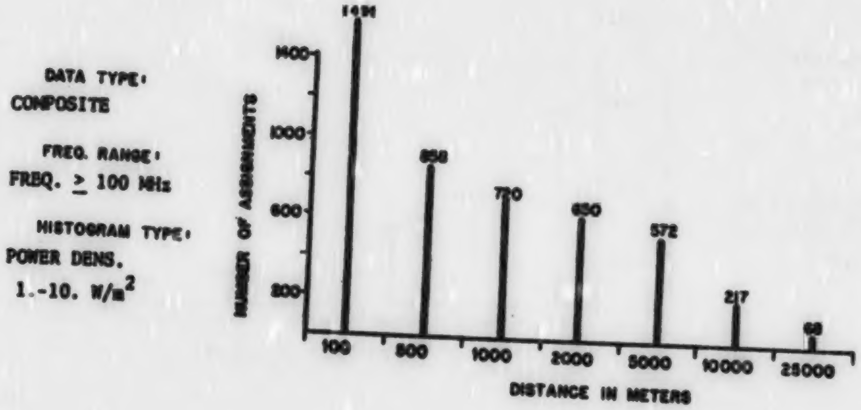
In February 1976, in conjunction with the environmental nonionizing radiation measurements being performed in Miami, EPA/ORP measured electric field intensities associated with microwave oven operation at a location outside a large condominium complex in Ft. Lauderdale, Florida.[11] Microwave ovens are installed in the kitchens of all of the condominium apartments. The ovens were manufactured to operate at a frequency which is nominally 915 MHz. The highest field intensity measured was 8.9 mV/m (2.1×10^{-5} μW/cm^2) and centered at 920 MHz, at a distance of approximately 500 feet from the complex and at a height of about 20 feet above ground. During the measurements, no more than three ovens were observed operating simultaneously, although it might be expected that more ovens could be. Frequency shifts, superimposing parts of the characteristic spectra of simultaneously operating ovens, could obscure the identification of other ovens operating at the same time.

Portable Traffic Radar Systems

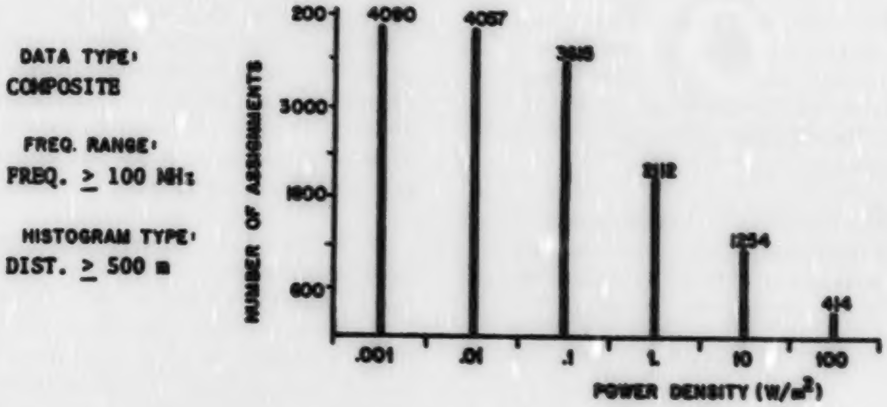
In March 1976, a study of typical portable traffic radar systems, used by police to determine the speed of vehicles, was completed.[12] The study was initiated by a request for information by the Amalgamated Transit Union, which was concerned about members' exposure. An analysis was performed to determine radiation characteristics of four different commercially available



Frequency Assignment Distributions: Number vs. Distance
for a Minimum on-Axis Power Density
Figure 6.6



Frequency Assignment Distribution Number vs.
Distance for a Specified Range of On-Axis
Power Density
Figure 6.7



Frequency Assignment Distributions: Number vs. Minimum On-Axis Power Density at a Specified Distance
Figure 6.8

traffic radar systems, and to predict on- and off-axis power densities at various distances from the radiation sources. It appears that use of traffic radars cannot result in significant exposures to persons in vehicles being checked by police radar.

Fetal Exposure in Rats

EPA/ORP conducted two long-term studies of rats exposed to different levels of radiation — 2450 MHz and 425 MHz. Preliminary results indicate that there may be an effect on the immune system; the Specific Absorption Rates (SARs) were measured in both studies.

The EPA/ORP Health Effects Research Laboratory developed the capacity for measuring average SARs for available exposure systems. Two pairs of twin well calimeters were constructed to measure whole body absorption on animals up to the size of adult rats.[13] In addition, two dosimetry studies were conducted: one applied the method of measuring heating and cooling curves to determine the SAR for *in vitro* samples;[14] the other described a simple method for measuring whole body absorption for small lab animals using common equipment.[15]

Length of Gestation

EPA/ORP is investigating the effects of chronic irradiation of mice at 2450 MHz on the length of gestation, since a pilot study indicated a significant lengthening of the duration of pregnancy. Also, a large number of mouse litters have been examined for teratological changes after daily irradiation *in utero* at 2450 MHz. Three exposure levels (3500; 14,000 and 28,000 μW/cm^2) were used, and a total of seven encephaloceles (hernias of the brain) were found in approximately 300 litters (3000 animals); no such anomalies were found in a similar number of controls. The normal incidence of this anomaly is three in 10,000. The significance of the results is being evaluated.

Animal Studies on Behavioral Effects

Several EPA/ORP behavioral studies are in progress for both acute and chronic irradiation of rats or squirrel monkeys. Subjects being investigated include changes in social behavior, in stress-related biochemical substances, EEG parameters, and performance after operant conditioning. Results from one such 1976 study show that rats irradiated (15,000 and 20,000 μW/cm^2, 2450 MHz) for 15 hours display at least a 40% decrease in task performance whereas one hour exposures show no decrease.[16] Lower powers did not produce statistically significant decreases in behavior after 15 hours of exposure, but the trend towards lowered performance was seen at power densities as low as five mW/cm^2.

A chronic study of behavioral effects is being performed at Stanford Research Institute. Pregnant squirrel monkeys are being exposed throughout gestation to 2450 MHz radiation, three hours per day, five days per week. Infants will be exposed on the same schedule to 12 months after birth. (Exposure levels are 100; 1000 and 10,000 μW/cm^2.) In addition to behavioral responses, biochemical and immunological parameters are being investigated. The exposures are currently in progress, but some unexpected results have been obtained; in the higher exposure level groups, there have been deaths of infants and mothers. Autopsies are being conducted to discover the cause.

Hearing Effects

The first phase of EPA/ORD's work to investigate the effect of microwaves on hearing using post stimulus time histograms from the auditory nerve has been completed. Evidence shows that transduction of the pulsed microwaves can be mechanical, through stimulation of hair cells or through direct stimulation of the auditory nerve.[17] This important work has not been continued because of the unavailability of funds.

Epidemiological Study of Alabama Children

The epidemiological study of congenital anomalies in children born at Ft. Rucker, Alabama, has been completed and the final report has been issued.[18] The investigators concluded that the available evidence did not support the thesis that there was a significantly higher than normal rate of anomalies. However, they also concluded that the measuring device, examination of birth records, was so insensitive that a very high anomaly rate would be necessary to measure a significant difference.

In Vitro Studies

EPA's *in vitro* work in progress is concentrating on the study of amplitude modulated microwave radiation on the normal processes of enzyme systems, bacterial and mammalian cells, and brain tissue. The development of a microwave spectrometer capable of identifying wavelengths of energy absorption for *in vitro* systems has encountered technical difficulty. The dual line instrument has been found to be technically unfeasible, and work is now concentrating on a single line instrument with data storage capability.

BRH Studies

Marine Radar Exposure

Following a study of microwave radiation exposure associated with marine radar units on small pleasure boats,[19] BRH concluded that people will probably not be exposed to more than 1000 $\mu W/cm^2$ average power density under normal operating conditions. However, significantly increased levels might result if antenna rotation is stopped.

Theoretical Dosimetry Studies

BRH developed a computer program to predict the absorbed power density at any point inside a body exposed to microwave radiation. Several calculations of the internal distribution of absorbed power have been made with a five-layered spherical model of the head and a triple-layered, irregularly shaped model of the human thigh.

Miniature Microwave Field Probe

A miniature probe, capable of measuring microwave fields in air or in simulated biological tissue phantoms, was developed by BRH. A fiber optics telemetry system was made, in microminiature form, to allow the probe to be used without a metallic signal cable which could diminish accuracy.

• High Voltage Transmission Lines

Private citizens, public interest groups, and State agencies have expressed concern about the potential adverse effects of electric power at extra-high voltages (EHV), i.e., voltages at or above 345 kilovolts. Because of these concerns, EPA published a notice in the *Federal Register* in 1975, requesting data and information on health and environmental effects of EHV power transmission.[20] Over 50 replies totaling over 6000 pages were received,[21] and in 1976, a request for proposals to evaluate and summarize the information received was prepared and made public. The proposals received in response have been evaluated in preparation for the award of a contract. Contractual arrangements will be made in 1977, and the desired evaluation and summary should be available by the end of the year.

An Interagency Advisory Committee on Electric Field Effects from High Voltage Lines has been established to coordinate Federally sponsored efforts relating to the environmental effects of electric fields from high voltage transmission lines. The Committee is chaired by ERDA.

• Lasers and Laser Products

Guidance

Before BRH's laser performance standard went into effect on August 2, 1976,[22] two documents were published to help manufacturers comply with it:

— "Laser Products — Federal Requirements for Manufacturers"[23] describes the major provisions, and explains the actions required of manufacturers and the consequences of noncompliance.

— "Guide for Submission of Information on Lasers and Products Containing Lasers"[24] is specifically directed at the reports the standard requires.

Compliance

BRH expanded its program to enforce the Federal laser product performance standard. In addition to developing and distributing laser field test kits, the Division of Compliance notified three manufacturers of noncompliance after the standard became effective.

To help manufacturers comply, BRH notified them of the availability of a laser power transfer meter. It will be maintained and calibrated by the National Bureau of Standards, and made available to industry for checking out their testing and quality control measurements for products subject to the laser standard.

Studies

Recent laser bioeffects data were reviewed at a BRH sponsored public meeting, to consider their implications for the Federal performance standards. Of special interest were data relevant to hazards of radiation in the red, blue and ultraviolet portions of the electromagnetic spectrum.

• Light Products and Devices

Guidance

Mercury Vapor Lamps

Following a reissuance in June of its warning against the hazards of broken mercury vapor discharge lamps, BRH issued a proposal in October 1976[25] recommending radiation safety performance criteria for them. All high intensity mercury vapor lamps used for general illumination would shut off within two minutes after their outer envelope is broken. (Normally the envelope prevents intense ultraviolet radiation from escaping from the inner bulb.) The Bureau has taken a dual approach to the hazard, cooperating with the American National Standards Institute to prepare a voluntary industry standard while developing concepts for a mandatory standard in case the other fails to materialize.

Studies

Light Research Programs Symposium

BRH reported on its light research activities at a symposium on Biological Effects and Measurement of Light Sources, which brought together all Bureau personnel, contractors and grantees working in the area. They exchanged information on their research and reviewed the status of ongoing projects.

Light Source Measurement

BRH awarded a contract to characterize and measure levels of radiation emission from various illumination sources, including high intensity gas discharge lamps, quartz halogen lamps, xenon flash lamps and strobe lights.

Ultraviolet Hazard Monitor

BRH sought proposals for ultraviolet radiation hazard monitors, including development, construction, testing and calibration. These are needed for evaluation of potentially harmful emissions from light emitting products, including sunlamps, laser pump sources, germicidal lamps, and high pressure gas discharge lamps used for general illumination.

Guide Number for Ultraviolet Radiation

BRH developed a "Maximum Illumination Guide" representing the maximum illumination level for which a particular type of light source may be used without exceeding a specified ultraviolet exposure limit. The Guide is useful for comparing the relative desirability of various light sources, responding to concern about potential hazards of ultraviolet radiation exposure.

Environmental Factors and Ultraviolet Injury

The Veterans Administration continued to evaluate the role of environmental factors on ultraviolet light injury. Some of the factors being examined are heat, wind; and humidity; it has already been found that these have an adverse effect on acute injury.

Monitoring Ultraviolet Radiation

Under contract to the Department of Transportation's System Development and Technology Office, Temple University was assigned to design and construct monitoring devices to measure ultraviolet light.

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EPA Technical Notes:

ORP/EAD 76–1
ORP/EAD 76–2

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FDA 76–8036
FDA 76–8037

FDA 76–8040
FDA 77–8002
FDA 77–8007
FDA 77–8010

OCCUPATIONAL EXPOSURE

• Introduction

People who are exposed to radiation on the job add a certain amount to the dose generally received — whether they are physicians, x-ray technicians, nuclear power plant operators, uranium miners, or fire alarm makers. Because such workers are usually subject to higher doses than the general population, it is important to know how many are exposed to how much radiation, and what effects it has on them, if any. Data collected on occupationally exposed people can be useful in assessing potential effects on the general public.

An initial problem is defining who a radiation worker is. As the partial list below shows, sources of occupational exposure to ionizing radiation are by no means confined to medical and nuclear fuel cycle activities. Industrial exposures include not only obvious sources like thickness gauges and radiographic equipment, but also incidental sources like klystron tubes and radar tube testing operations.

Since there is so much room for dispute about who a radiation worker is, the number of workers exposed is uncertain. The Special Studies Group estimated in a 1972 EPA report that there were 772,000 such employees in 1969-70, "using reported numbers of workers [from the Atomic Energy Commission, other agencies, and medical and dental sources] and judicious estimates in nonreported ones [such as nonreporting Agreement States and AEC licensees]."[1] The total man-rem from occupational exposure was calculated at 164,000, with a mean annual dose of 210 mrem/worker.

Information about exposure is needed not only to insure compliance with applicable regulations but also to provide a data base for studies of health effects. Since cancer is the main known effect of ionizing radiation exposure, and since it may arise from any of many sources, continuing epidemiological studies of workers are especially informative.

According to EPA's Office of Radiation Programs' (EPA/ORP) May 1976 *Radiological Quality of the Environment*, "there is no requirement for uniformity in collecting and reporting occupational exposures. There are considerable variations in the terminology used by reporting agencies. For example, results of personnel monitoring data are reported as exposures (R), absorbed doses (rad) or dose equivalents (rem)."[2] The Federal Government maintains two registries which cover occupational exposure information, ERDA's Transuranium Registry and BRH's Radiation Incidents Registry. Both are voluntary.

Occupational exposure to nonionizing radiation is also surprisingly widespread. Lasers, for example, are used in the construction industry as reference lines — and in drilling, communications, holography, and surgery. (They are extremely hazardous to the worker's eye because of the intense concentration of light on the retina.) Microwaves, which are widely used in medical diathermy and other fields as well as in ovens, can affect eyes, and may have a health impact at low levels over a long period of time. For those who work out of doors, sunlight is a major source of ultraviolet light which may cause cancer, and certainly has irritating and damaging effects on the eye.

Federal responsibilities and selected activities related to radiation exposure are discussed below, categorized by agency. The information presented is far from exhaustive, but we hope that it will provide a sense of the diversity of occupational exposure and of the activities of Federal agencies which regulate it.

Workers Who May Be Exposed to Ionizing Radiation

- Aircraft workers
- Atomic energy plant workers
- Biologists
- Cathode ray tube makers
- Ceramic workers
- Chemists
- Dental assistants
- Dentists
- Dermatologists
- Drug makers
- Drug sterilizers
- Electron microscope makers
- Electron microscopists
- Electrostatic eliminator operators
- Embalmers
- Fire alarm makers
- Food preservers
- Food sterilizers
- Gas mantle makers
- Glass makers
- High voltage television repairmen
- High voltage vacuum tube makers
- High voltage vacuum tube users
- Industrial fluoroscope operators
- Industrial radiographers
- Inspectors using, and workers in proximity to, sealed gamma ray sources (cesium-137, cobalt-60 and iridium-192)
- Klystron tube operators
- Laboratory technicians
- Liquid level gauge operators
- Luminous dial painters
- Machinists, fabricated metal product
- Military personnel
- Nurses
- Oil well loggers
- Ore assayers
- Pathologists
- Petroleum refinery workers
- Physicians
- Physicists
- Pipeline oil flow testers
- Pipeline weld radiographers
- Plasma torch operators
- Plastic technicians
- Printing press workers
- Prospectors
- Radar tube makers
- Radiologists
- Radium laboratory workers
- Radium refinery workers
- Research workers
- Roentgenologists
- Roentgen tube makers
- Shoe fitters
- Television tube makers
- Thickness gauge operators
- Thorium-aluminum alloy workers
- Thorium-magnesium alloy workers
- Thorium ore producers
- Tile glazers
- Uranium dye workers
- Uranium mill workers
- Uranium miners
- Veterinarians
- X-Ray aides
- X-Ray diffraction apparatus operators
- X-Ray technicians*

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*From *Occupational Diseases: A Guide to Their Recognition,* PHS Public Notice 1097, p.270-271 (Reprinted June 1966).

• Summary

EPA/ORP

— worked on updating the Federal guides for limiting occupational exposure to ionizing radiation, with the help of an Interagency Committee.

— responded to a petition for special standards for "hot particles."

NRC

— collected extensive annual radiation exposure records from its licensees.

— resolved areas of duplicative regulation with the Labor Department.

— asked all licensees to submit a voluntary report of 1975 personnel monitoring data, to help determine the value of the information submitted now and whether more should be collected.

— responded to a petition for special standards for "hot particles."

— promulgated new rules on respiratory protection, high intensity radiation, dosimetry requirements for criticality accidents, and monitoring for radiographers.

— issued an environmental impact statement on personnel neutron dosimeters.

— conducted or funded studies on exposure of airport workers and flight attendants.

ERDA

— published its annual report of occupational exposure.

— conducted lifetime health and mortality studies, as well as investigating bioeffects on uranium miners, radium workers, and inhaled radioactive gases and dust.

MESA

— increased its standards compliance and monitoring activities, in part by conducting blitz inspections lasting two or three weeks.

— made progress toward promulgating new sampling, recordkeeping and ventilation standards.

— conducted research in radiation protection.

OSHA

— continued to cover radiation protection as one of many criteria during its inspections.

NIOSH

— sponsored studies of current trends in survivorship of radiologists, and of safe ocular levels for near-infrared exposures.

BRH

— continued analysis of data from the Radiation Registry of Physicians.

— discussed with other agencies implementation of a testing program for personnel dosimeters.

— maintained the Radiation Incidents Registry.

• Environmental Protection Agency

EPA/ORP worked on updating the Federal guides for limiting occupational exposure to ionizing radiation. The former Federal Radiation Council's 1960 "Radiation Protection Guidance for Federal Agencies"[3] is the basic document used by agencies in preparing standards and regulations for their respective areas of authority. In the seventeen years since the Guidance was issued, the number of workers exposed to ionizing radiation has increased and more information has been developed about the potential risks.

EPA/ORP set up an Interagency Committee on Occupational Exposures to Ionizing Radiation in September 1974, to advise the Agency in developing new guides sufficient to protect radiation workers from undue risk. Four major issues associated with occupational exposure have been identified by the Committee:

— *Determination of the basic Radiation Protection Guides (RPG's)*

Selecting the RPG's on the basis of a cost benefit analysis appears not to be feasible because there are so many uncertainties in assesssing all uses of radiation sources in the country. Instead, EPA/ORP is examining a comparative risk approach, combined with consideration of other relevant factors.

In this approach, the risk associated with being exposed to radiation is compared with the risk involved in non-radiation occupations. An EPA/ORP analysis[4] found that a radiation worker exposed at five rems per year faces a risk no greater than that of a worker in an industry with an average risk of accidental death. The analysis continued in 1976, including use of a detailed model to refine the evaluation of risk to different age groups.

— *Use of the accumulated exposure rule*

Under current Guidance, cumulative exposure of radiation workers is limited to a number of rems dependent on the age (N) of the worker. The formula allows 5(N-18) rems of cumulative exposure and up to three rems per quarter; thus, a radiation worker could be exposed to 12 rems in a single year (at three rems/quarter) if a sufficient "exposure bank account" had accumulated using the 5(N-18) rule. This rule is being reexamined, since it is not uniformly applied and may not be necessary.

— *Assurance that exposures are as low as practicable (ALAP)*

EPA/ORP is examining potential mechanisms to assure that exposures below the RPG's will indeed be as low as practicable, such as requiring more administrative surveillance or monitoring when radiation exposure is increased.

— *Provisions for exceeding the RPG's and other special situations*

The RPG's may have to be exceeded in some planned activities. Other special situations also require consideration, such as those of fertile women, transient workers, minors, and students.

EPA worked toward proposed resolution of these and other issues, which will be discussed in a technical document supporting proposed updated Federal guidance. Draft revised guidance, prepared during 1976, will be reviewed by the Interagency Committee in 1977 and finalized for public comment.

To back up its guidance efforts and to assess current exposure levels, EPA/ORP began developing a program to compile statistical data on annual occupational exposure to ionizing radiation. A contract was awarded in 1976 to investigate ways to assemble national data, and final results are expected during 1977.

EPA's response to a petition for special standards for "hot particles" is discussed below.

• Nuclear Regulatory Commission

For the calendar years 1968 through 1975, NRC collected 417,000 annual radiation exposure records ("whole-body" exposures) from its various licensees. About 95 percent of these record an annual exposure of less than two rems per person, and 22 recorded more than 12 rems. Only one such exposure was reported in each of the last three years of the period. More than half of the 79,000 exposures reported in 1975 were too small to be detected by personnel radiation monitoring devices, and more than 99 percent of the total were less than five rems. The average exposure for 1975 was 0.36 rem per person.[5] (1975 is the most recent year for which data are available, see Tables 7.1, 2, 3 for details.)

The Occupational Safety and Health Administration accepts NRC's certification that Agreement State radiation control programs are adequate to protect the public and radiation workers. OSHA does not assert its own regulatory authority over agreement material activities in Agreement States under the Occupational Safety and Health Act. During 1976, it was noted that there were areas of duplicative regulation for licensees possessing both Agreement and non-Agreement sources in relation to occupational safety and health programs. NRC and Labor Department staffs resolved these issues cooperatively and notified the Agreement States of the results.

Table 7.1

SUMMARY OF ANNUAL WHOLE BODY EXPOSURES FOR COVERED NRC LICENSEES

1968 - 1975

Year	Total Number Monitored	Percent of Exposures <2 Rems	Number of Annual Exposures >12 Rems
1968	36,836	97.2%	3
1969	31,176	96.5%	7
1970	36,164	96.1%	0
1971	36,311	95.3%	1
1972	44,690	95.7%	8
1973	67,862	95.0%	1
1974	85,097	96.4%	1
1975	78,713	94.8%	1

Table 7.3

NRC TRANSIENT WORKERS

1969 - 1975

	1969	1970	1971	1972	1973	1974	1975	Totals
Number of Workers Terminating employment with Two or More Employers in One Quarter	8	28	14	66	154	313	530	1113
Total Number of Man-rems	5.4	12.6	2.9	58.2	127.4	160.7	330.8	698.0
Average Individual Quarterly Exposure	0.67	0.45	0.20	0.88	0.83	0.51	0.62	0.63

TABLE 7.2

DISTRIBUTION OF ANNUAL WHOLE BODY EXPOSURES REPORTED BY COVERED LICENSEES-1975

Covered Categories of NRC Licensees	Total No. Monitored	Exposure Ranges (Rems)																	
		Less than Measurable	Meas'ble <0.10	0.10 0.25	0.25 0.50	0.50 0.75	0.75 1.00	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>-12
Power Reactors	54763	26729	10606	4081	2948	1778	1384	3982	1873	692	424	169	60	24	12	0	1	0	0
Industrial Radiography	9178	4485	1811	813	614	346	263	538	171	64	35	21	8	1	3	1	2	1	1
Fuel Processing & Fabrication	11405	5910	1968	1102	1021	433	241	381	153	77	40	30	11	9	14	15	0	0	0
Manufacturing & Distribution	3367	1508	644	532	214	88	67	140	65	43	39	11	12	3	0	1	0	0	0
Totals	78713	38632	15029	6528	4797	2645	1955	5041	2262	876	538	231	91	37	29	17	3	1	1

Guidance

Personnel Monitoring Reports

Since 1969, four categories of licensees have been required to report annually the results of their personnel monitoring for radiation exposures (nuclear reactors, industrial radiographers, nuclear fuel processors and reprocessors, and certain manufacturers or processors of large quantities of by-product material). These are believed to include licensees whose operations have the greatest potential for significant occupational radiation exposures.

On May 30, 1975, the NRC published a proposed amendment[6] to its regulation that would require *all* licensees to file an annual statistical summary report. The data gathered would be used to identify situations for further study. This would enable the NRC to develop guidance on keeping occupational radiation exposures "as low as is reasonably achievable." The NRC believes the information it would receive from all licensees is needed for evaluating the risk of exposure associated with related activities.

However, a number of comments received on the proposed rulemaking questioned the value of the data requested and mentioned the burden of reporting by licensees. Consequently, the NRC asked all licensees to submit a voluntary, one-time report of their personnel monitoring data for 1975. These reports will provide NRC with better basis for assessing the value of the data. In addition, they will determine whether or not the licensees who are currently required to report actually conduct operations having the greatest potential for significant radiation exposure. The NRC will evaluate the reports before deciding on a requirement for reporting from all licensees.

Petition on "Hot Particles"

On April 12, 1976, the NRC published in the *Federal Register*[7] a comprehensive analysis of what have been called "hot particles" of plutonium. Small particles of an alpha-emitting radionuclide such as plutonium, when deposited in the lung, can cause extremely large radiation doses to the tissue cells immediately surrounding the particles. Despite the large doses, however, experiments with animals have indicated that cancer is not likely to develop unless large volumes of tissue are irradiated, as would be the case with uniformly distributed radioactive material in the lung. In addition, clinical studies have established that workers exposed to airborne plutonium particles immediately following World War II have not developed lung cancer. The NRC analysis concluded that radionuclides in the form of particles are not *more* hazardous, and may be less hazardous, than the same quantity of radionuclides distributed uniformly in the lung.

The analysis was performed as the result of a petition from the Natural Resources Defense Council, which asked NRC to establish special standards for plutonium and other alpha emitters in "hot particle" form. The standards were to be a factor of 115,000 lower than present standards for these radionuclides in insoluble form. The Commission denied the petition. EPA was also asked to respond, and also denied the petition following a National Academy of Sciences review of the scientific basis. In October, EPA published the full text of the Academy Committee's report, "Health Effects of Alpha-Emitting Particles in the Respiratory Tract."[8] It concluded "that the evidence does not support the NRDC petition," and that "if there is a hot particle risk, it is small by comparison with the lung cancer risk attributable to the generalized alpha radiation." EPA published a denial of the NRDC petition on January 6, 1977 (42 F.R. 1288).

The question raised by the petition was also reviewed by the National Council of Radiation Protection and Measurements (NCRP). The Council published "Alpha-Emitting Particles in Lungs" which concluded that "particulate plutonium in the lung is no greater hazard than the same amount of plutonium more uniformly distributed throughout the lung."[9]

Respiratory Protection

The NRC adopted a rule change[10] in August 1976 that:

— eliminates separate licensing actions for approval of respirator use,

— relaxes the requirements for reporting overexposures to radioactive materials taken into the body, by replacing the former weekly reporting limits with quarterly limits consistent with basic radiation protection standards, and

— establishes requirements for precautionary procedures, including a weekly basis for exposure control and the use of engineering controls, to limit exposures to airborne radioactive materials.

The rule is expected to improve safety requirements and result in significant savings by eliminating unnecessary reports from licensees. A regulatory guide[11] and a supplemental manual of technical support information[12] were published in October 1976 to provide licensees with the necessary guidance on practices for respiratory protection that are acceptable to the NRC.

High-Intensity Radiation

In May 1976, the NRC published a proposed rule change[13] to upgrade requirements for protection against radiation from high-intensity sources, such as those used in some irradiators, that could be immediately lethal to people who might accidentally be exposed to them.

The proposed rule would require automatically functioning entry controls and warning devices, as well as procedural controls, to reduce the likelihood of exposures. Potentially affected licensees were provided with information on costs and need for the additional controls.

Dosimetry Requirements for Criticality Accidents

In July 1976, the NRC issued a rule change[14] to enable rapid screening of personnel who might have been exposed to radiation during a criticality (nuclear chain reaction) accident. It requires people who work near fissionable materials that could form a critical mass to wear a device (such as an indium strip) to identify exposed workers quickly should an accident occur. Use of a dosimeter to measure the neutron dose is not required, on the basis of an analysis which indicated that neutron dosimetry would cost more than the value of the dose information for attending physicians.

Monitoring of Radiographers

An amendment to NRC regulations on personnel monitoring,[15] placed in effect in May 1976, permits radiographers to use thermoluminescent dosimeters as substitutes for film badges to record cumulative individual exposure to radiation. The amendment requires daily exposure records obtained with dosimeters that are readable without the use of accessory equipment.

Environmental Impact Statement

Personnel Neutron Dosimeters Containing Natural Thorium

Description: NRC's Office of Standards Development issued a Draft Statement in June 1976[16] on a manufacturer's request for exemption from licensing requirements for personnel dosimeters containing natural thorium. Thorium is an essential ingredient for producing fission fragments to be recorded as tracks in an adjacent plastic foil from which the neutron exposures can be estimated. The Final Statement was published in January 1977 as NUREG-0137, "Final Environmental Statement Concerning Exemption from Licensing Requirements for Personnel Neutron Dosimeters that Contain Natural Thorium."

EPA/ORP Response and Status: EPA/ORP rated the Draft Statement lack of objections/insufficient information. In addition to requesting further analysis regarding the maximum exposed individual in airplanes (one leg of the distribution network), EPA/ORP questioned the effect of the thorium dosimeter on other dosimeters.

Studies

Exposure of Airport Workers

An NRC contractor's report issued in February 1976[17] gave the results of surveys of exposures to cargo handlers at six U.S. airports. The information gathered included descriptions of handling and arrangement of packages, dose distribution around groups of packages, and estimated doses received by workers.

As its major conclusion, the study showed that no monitored worker received a dose equivalent greater than nine mrem in a single shift: 12 received more than five mrem, and 39 more than three mrem. A combined total of 102 shifts, 125 workers, and more than 1500 packages were covered. No evidence was found to suggest that the public received any exposure of significance relative to natural background dose levels.

Exposure of Flight Attendants

NRC and two flight attendants' unions sponsored jointly a study which concluded that there is little increase in the radiation exposure of flight attendants due to radioactive shipments. Data was gathered by dosimeters worn by about 100 attendants, and it was found that the average annual dose equivalent from shipments was 11 mrem. About 100 to 150 mrem per year is the dose from cosmic radiation.

• Energy Research and Development Administration

ERDA is responsible for the occupational safety and health both of its own Federal employees and of those who work for its contractors. Under the Occupational Safety and Health Act, Federal employees must be protected by a program comparable to the Act's, and contractor employees are covered by the agency's ongoing program. To carry out ERDA's responsibilities, a management directive system has been developed.

An annual report of radiation exposures for ERDA and ERDA contractor employees is published each year, covering the previous calendar year. As an outgrowth of the old Atomic Energy Commission's program to retain certain records in a central repository, the annual report was issued by ERDA for the first time in 1974.[18] Among the information presented in 1976 is a whole body exposure history, the distribution of exposures by facility type, and summaries of internal exposures.[19]

Studies

Lifetime Health and Mortality Studies

ERDA accumulated data on about 37,000 Hanford project employees, covering medical and occupational exposure, medical examinations and mortality data. The Hanford Environmental Health Foundation was granted funds to analyze the data to assess the effect of exposure on mortality rate and causes of death. Also, the National Cancer Institute undertook a study to determine whether 33,500 employees at the Hanford facility were harmed by their exposure to permissible levels of radiation, using the disability claim rate as the criterion of health.

Uranium Miners

ERDA sponsored a study to find whether uranium miners can reverse the cytological progression to malignancy, once it has started, by stopping mining or cigarette smoking or both. To identify which specific uranium mine air contaminants are responsible for development of respiratory tract pathology, the Batelle Memorial Institute conducted experiments with beagles and rodents. Also, the exposure of miners to radon with lead-210 was evaluated at New York University.

Health Effects of Radium and Thorium

Radium cases were traced by the Argonne National Laboratory from lists of workers with

Table 7.4

WHOLE-BODY EXPOSURE HISTORY OF ERDA AND ERDA CONTRACTOR EMPLOYEES

Year	(Percent of employees with dose equivalent greater than) 1 rem (number)	2 rem (number)	Total Man rem*	Total Monitored
1964	4.85 (6254)	2.07 (2671)	13411	128965
1965	5.07 (6854)	1.99 (2696)	14818	135214
1966**	5.35 (7387)	1.98 (2738)	15454	137939
1967**	6.11 (6622)	2.23 (2415)	13715	108386
1968	4.43 (4780)	1.83 (1981)	9877	107986
1969	4.17 (4293)	1.69 (1739)	8707	102918
1970	4.63 (4476)	1.84 (1778)	9137	96661
1971	3.90 (3675)	1.37 (1295)	5395	94315
1972	3.78 (3383)	1.40 (1253)	6170	89460
1973	3.16 (2906)	1.05 (962)	5623	91977
1974***	3.26 (2549)	1.13 (882)	4935	78232
1975	3.36 (2974)	1.28 (1128)	5813	88425

*Individuals with dose equivalent of less than one rem have been excluded. In 1975, this represented approximately 50 percent of the total man rem. Therefore, these data reflect only the trend in high ranges of dose equivalents rather than the total collective dose equivalent.

**Data for 1966 and 1967 differ from previous reports due to the discovery of an error in the radiation exposure records of one major contractor.

***These data differ slightly from that reported in ERDA-76/119 because of the late reporting of exposures for 227 individuals.

Table 7.5

Length of Employment for Workers Terminating Employment with ERDA or ERDA Contractors

	Calendar Year	1-89 Days	90-180 Days	180-365 Days	1-2 Years	2-4 Years	4-6 Years	>6 Years
Total Number	1975	2016	700	677	743	509	329	1612
Total Cum. Dose Equivalent (Rem)		519.40	192.37	292.68	399.57	316.58	480.18	4171.88
Avg. Cum. Dose Equivalent (Rem)		.26	.27	.43	.54	.62	1.46	2.59

luminous paints and other radiation sources. Epidemiological analyses planned include correlating morbidity and mortality in relation to the body burden of radium. Also, ERDA funded collection of technical data on radium-burdened persons for whom late effects are being evaluated. Along with conclusions about the risks of different cancers, the study indicates that significant chromosome effects appear in persons in the high risk range.

The Argonne National Laboratory's Center for Human Radiobiology continued its studies of the health of former thorium workers, searching out mortality records for age, sex, time, and cause-specific mortality. The results will be compared to the expected figures for the general population, and figures for job classification subgroups will be analyzed and compared.

Inhaled Radioactive Gases and Dusts

ERDA sponsored a University of Rochester study of the effects of radon or its decay products. It is designed to determine whether they, through the emission of alpha particle radiation, could be the stimulus to produce the lesions which develop into bronchial cancer, or whether other carcinogenic agents must be present.

• Mining Enforcement and Safety Administration (MESA)

MESA's radiation standards compliance and monitoring activities increased dramatically in 1976, in regulating both uranium and other mines where radiation could be a problem.[30] Forty-nine notices and 14 orders were issued, as opposed to 22 and 16 respectively in 1975. A total of 2,251 radiation (radon daughter) samples were collected during 378 inspections at 296 underground mines: 191 inspections in 142 uranium mines, and 187 in 154 others. (In 1975, 1398 samples were taken during 253 inspections at 147 mines.)

Table 7.6 summarizes Federal sampling results for 1976. The data for nonuranium mines seem high because of one large phosphate mine, where a problem was discovered and certain sections were permanently abandoned. Aside from that case, average radon daughter concentrations were 0.14 working level (WL;see glossary) and the maximum was 3.02 WL.

Both Federal sampling results and company records show a slight decrease in 1976 radon daughter concentrations — from 0.71 WL to 0.58 WL and from 1.07 working level months (WLM) to 0.99 WLM. However, the percentage distribution of sample results and exposures is relatively unchanged. See Table 7.7 for mining company data.

The discrepancy between Federal inspection results and company records of worker exposure continued to be marked in 1976: 4.64 average exposure compared to 0.99. MESA therefore expanded its special radiation audit program,

Table 7.6 - Radon daughter concentrations, 1976

Type of mine	Total number of samples	Average concentrations	Maximum concentrations	Number of samples in designated range				
				0.0-0.3 WL	0.3-0.6 WL	0.6-1.0 WL	1.0-2.0 WL	>2.0 WL
Uranium mines	1,180	0.58 WL	22.5 WL	628	217	189	87	59
Nonuranium mines	1,071	0.22 WL	5.4 WL	837	91	86	54	3

Table 7.7 - 1976 uranium mine exposure

Total employment	Average exposure	Miners having exposure in indicated intervals, percent				
		0-1 WLM	1-2 WLM	2-3 WLM	3-4 WLM	>4 WLM
4,306	0.99 WLM	60.4	22.0	11.4	6.0	0.1

sending teams to visit four underground uranium mines employing more than 600 miners. Blitz inspections lasting two to three weeks indicated three related problems:

— because radiation levels were far more variable than operators assumed, sampling was not frequent enough;

— as operators did not average their sampling data properly, high radiation levels were seldom reflected in employee exposure records; and

— since ventilation was not adequately planned or maintained, adjusting it in one area almost invariably caused a problem in another.

As a result of the special radiation audits, some operators have modified their recordkeeping procedures and sampling strategies to account properly for time spent by miners in high concentrations. When such conditions were found during the audits, orders withdrawing the workers from the area were issued until the radon daughter concentrations were reduced to acceptable levels. (This was usually done by State mine inspectors, since most of the audits were conducted in States where MESA delegates its authority.)

New sampling, recordkeeping and ventilation standards were provided[31] in 1975, and during 1976 the process of public comment brought them closer to promulgation. When finalized, they will help assure that mine workers are not overexposed.

MESA also conducted research in the radiation protection area in 1976. For example, personal dosimeters for alpha radiation which are suitable for the mining environment are in the advanced stage of field testing, and radon gas control technology is being developed.

• Occupational Safety and Health Administration

Simply put, the Department of Labor's Occupational Safety and Health Administration (OSHA) has jurisdiction over workers who are exposed to radiation but not covered by other agencies. OSHA inspects workplaces (where there is even one employee) for compliance with dozens of standards — of which radiation is only one. Therefore, there are no definite figures on the number of workplaces or workers that OSHA is responsible for, in terms of radiation protection alone.

The breadth of situations involved is enormous, from electron microscope workers to pipefitters. Although the Occupational Safety and Health Act covers Federal contractors as a matter of form, in practice the agencies contracting with them are responsible for enforcement. Federal employees, while not covered under the Act, are to be protected by a comparable agency plan.

• National Institute of Occupational Safety and Health

NIOSH, which conducts research and makes recommendations to OSHA regarding standards, had two 1976 projects with particular bearing on radiation protection: a Johns Hopkins University study of current trends in survivorship of radiologists, and a Duke University study of safe ocular levels for near-infrared occupational exposures.

The study of radiologists is designed to determine whether they are still subject to a greater risk of cancer than other doctors, despite the decreased dose of radiation to which they have been exposed in recent years. In addition, the research will attempt to identify dose levels of radiation and other toxic agents to which various medical specialty groups are exposed, and to relate these data to cause-specific mortality.

At Duke University, researchers plan to determine non-hazardous power levels and the mechanism of formation of cataracts following chronic occupational exposures to radiation in the near infrared. Among other procedures, lenses will be analyzed by sensitive tests to detect any early or precataract changes following exposure.

• Bureau of Radiological Health

Although the primary responsibility for occupational health and safety enforcement lies with other agencies (particularly OSHA), FDA's Bureau of Radiological Health (BRH) conducted numerous pertinent programs in 1976, as for example:

— Analysis of the Radiation Registry of Physicians data proceeded, but BRH terminated its support for collection of further data. The Registry is a long term followup study of radiologists and pathologists and their families, to investigate bioeffects of prolonged occupational exposure to low levels of ionizing radiation.

— BRH, NRC, and ERDA held a public meeting to discuss the implementation of a testing program for personnel dosimeters. If the program can be successfully implemented, the NRC plans to amend its regulations to require its licensees to use dosimeter services that have been tested and found to meet certain accuracy requirements. ERDA is interested in extending the program to its contractors, while BRH intends to encourage use of the program by those who provide dosimeter services to users not regulated by the NRC.

BRH also maintains the voluntary Radiation Incidents Registry, which includes occupational data. 1970–1976 data are presented in Table 7.8. Other BRH programs relevant to occupational aspects of radiation protection are discussed in the chapter on Medical Radiation Exposure.

Table 7.8

Number of Incidents and Number of Persons Reported Accidentally Exposed to Various Types of Radiation Sources, Radiation Incidents Registry, 1970-1976.

Sources	1976		Cumulative 1970-1976	
	Number of incidents	Number of persons	Number of incidents	Number of persons
Ionizing				
Industrial x-ray units	2	4	82	92
Medical and Dental x-ray units	15	21	79	146
X-ray units in universities and laboratories	3	4	44	55
Gamma	-	-	6	14
Television	-	-	1	1
Nonionizing				
Ultraviolet	8	73	318*	463*
Microwave	1	2	52	65
Laser	-	-	21	23
High Frequency Radiowaves	-	-	11	11
Infrared	1	1	2	2
Ionizing and Monionizing	-	-	5	5
Ultrasound	-	-	3	5
Unknown	-	-	2	2
TOTAL	30	105	626	884

* This includes approximately 209 claims involving 232 persons allegedly injured from a defective ultraviolet dental device.

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19. *Eighth Annual Report of Radiation Exposures for ERDA and ERDA Contractor Employees, 1975.* ERDA: ERDA 77–29.

20. *Administration of the Federal Metal and Nonmetallic Mine Safety Act (PL 89–577), 1975.* U.S. Department of the Interior, Mining Enforcement and Safety Administration and Bureau of Mines.

21. "New and Revised Health and Safety Standards, Notice of Proposed Rulemaking." MESA, 40 F.R. 44272 (September 25, 1975).

Below are publication numbers for relevant items cited in Appendix B.

EPA Technical Reports: 520/4–76–013

ERDA Publications: ERDA 76–45–7, ERDA 76/119

NRC Publications: NUREG-0041, NUREG-0074, NUREG-0019

NRC Regulatory Guides: 4.13, 8.14, 8.15

BRH Technical Publications: FDA 77–8007

COMPREHENSIVE EXECUTIVE ACTIVITIES

This Chapter covers activities which cross the boundaries established in the others, such as regulations on ocean dumping of many kinds of radioactive waste, and research on low level radiation effects.

Guidance

Transuranium Contamination

EPA's Office of Radiation Programs (EPA/ORP) continued work on its assessment of the hazard to people from existing transuranium element contamination, with a view to proposing recommendations in 1977 for protecting exposed individuals and the environment. Plutonium and other transuranium elements have entered the environment from several sources: fallout from aboveground nuclear weapons tests (primarily during 1945-63), accidents involving military and related operations, and local releases from nuclear facilities. In developing possible recommendations, EPA/ORP has had valuable assistance from an Interagency Working Group with representatives from ERDA, NRC, NASA, and the Departments of Defense, State, Commerce and Interior. After being approved, EPA/ORP's recommendations will be issued as Federal Guidance. It will be implemented by the agencies with regulatory and administrative responsibilities for the production, utilization and control of transuranium elements.

Radioactivity in Food

FDA's Bureau of Radiological Health (BRH) distributed for review a draft guideline on response planning for incidents involving radioactive contamination of human foods and animal feeds. It is intended for use by Federal, State, and local agencies in planning protective countermeasures to institute, if food supplies become contaminated as a result of radiological incidents at nuclear facilities, transportation accidents, or fallout. The proposed recommendations would be Protective Action Guides, defined as the projected dose equivalent to individuals in the general population that warrants protective action.

Ocean Dumping

During 1976 EPA/ORP finalized a proposed revision of regulations on ocean dumping of wastes to include a basic isolation and containment philosophy for radioactive wastes.[1] High level radioactive wastes are prohibited from disposal. To prevent other radioactive wastes from being directly dispersed or diluted in ocean waters, they must be packaged so that:

— the wastes will radiodecay to environmentally innocuous materials within the life expectancy of the containers, and

— the wastes would produce only short-term localized adverse effects if the containers should rupture, and

— containers are dumped where they will cause no threat to navigation, fishing, shorelines or beaches.

Quality Assurance Requirements

EPA/ORP started writing quality assurance requirements for approved laboratories in 1976. The present draft generally requires use of approved procedures, following certain mandatory requirements in laboratory practice, establishment and operation of an internal quality control system, and satisfactory results on an annual performance evaluation.

Mandatory practice requirements include:

— Provision of a separate counting room with adequate temperature control, regulated power, and grounding,

— sample preparation equipment,

— appropriate counting instrumentation including specific types,

— sample preservation,

— participation in a quality control program including:

a. Semiannual participation in EPA/ORP intercomparisons.

b. Annual participation in an EPA/ORP unknown performance study.

c. Calibration procedures and records.

d. Routine internal quality control of duplicates, performance standards, and blanks.

Recommended but not mandatory guidelines cover personnel qualifications, laboratory space and utilities, glassware cleaning, quality of reagents and of water, handling and storage of radioactive standards and wastes, and data reporting and retention.

Proposed Guides for NARM

The National Conference of Radiation Control Program Directors appointed a Task Force which wrote and distributed draft guides on naturally-occurring or accelerator produced material (NARM). These materials are not covered by the Atomic Energy Act, and a mechanism is needed for Federal/State control of their manufacture and distribution. Among the provisions of the proposed guides are comprehensive classification and evaluation of NARM sources and products by radiation control agencies. Evaluation could be done in three ways: (1) by a State alone, (2) with BRH assistance, or (3) by BRH at the State's request.

Transportation Regulations

The Department of Transportation consolidated its regulations for air, water, rail and highway transportation of hazardous materials into a single volume, Title 49 of the Code of Federal Regulations. At the same time, some changes were made relating to radioactive substances specifically; for example, more information is to be included on the shipping paper description, and the standard radiation symbol will be used for vehicle placards.

The Federal Railroads Administration reviewed regulations and handling criteria for transporting radioactive materials by train, and concluded that no changes were required.

Radioactivity in the Great Lakes

An Interagency Working Group, chaired by EPA and including NRC and State members, completed development of "Refined Radioactivity Objectives for the Great Lakes," as provided for in the 1972 U.S.-Canadian Agreement on the Great Lakes. These objectives were discussed with a Canadian counterpart group; a mutually satisfactory draft was agreed to and forwarded to the U.S. State Department and Canadian Department of External Affairs for further intergovernmental consideration.

Studies

EPA/ORP's Research Committee

Following an Office of Management and Budget decision that ERDA, not EPA/ORP, has primary responsibility for ionizing radiation research, EPA/ORP created a formal Research Committee with two primary functions:

1. *On research pertaining to ionizing radiation,* to act as a mediator between (a) agencies with research responsibilities, and (b) the needs identified by EPA/ORP. Ultimately, the research is used to set radiation standards, assist in making technological decisions, or understand the problems associated with movement and analysis of radionuclides in the environment.

2. *On research pertaining to nonionizing radiation,* to perform a parallel mediating function, but within EPA/ORP itself as well as between it and other agencies.

The Committee is responsible for identifying EPA/ORP's top priority research and operational needs, and matching those to actual or potential activities in other agencies.

Plutonium Air Inhalation Dose (PAID)

To determine the dose and dose rates due to intake of the transuranic (class Y) elements and their decay products, EPA/ORP developed a computer code titled PAID, Plutonium Air Inhalation Dose. It is the first code which can determine the dose from parent-daughter chains accurately, including an assessment of the time dependent dose rates and doses from an acute or chronic, inhaled or ingested radionuclide. The code also provides for including the dose due to transfer of radioactivity to body organs from ingested materials. Recent modifications allow study of class W radionuclides as well as class Y.

Among the unique features of the PAID code are:

— explicit calculation of the dose rates and doses due to both parent and daughter products,

— inclusion of the dose to the tracheobronchial region due to the clearance of material deposited in the pulmonary region,

— calculation of the dose from material permanently retained in the lymph nodes, and

— separate calculation and printout of the percentage of the total dose to a reference organ due to absorption from the gastrointestinal tract for both parent and daughter.

Ocean Disposal Studies

Since 1974, the EPA Office of Radiation Programs has conducted a series of environmental assessment surveys at three of the four primary radioactive waste disposal sites used by the U.S. between 1946 and 1970. They are located in the Pacific Ocean west of San Francisco and in the Atlantic Ocean east of the Maryland-Delaware coast. Although ocean dumping of radioactive wastes by the United States was discontinued in 1970, it is being reconsidered because of recent problems with existing land burial sites and a national policy to reevaluate all radioactive waste management alternatives. EPA has the regulatory authority for the ocean disposal option under the Marine Protection Research and Sanctuaries Act of 1972 (PL 92-532).

Two basic conclusions have emerged from 1974 and 1975 studies, as background for the 1976 activities:

— Techniques formerly used to package the radioactive wastes for ocean disposal were, in general, not adequate to insure that the wastes would remain isolated from the surrounding environment until they had radiodecayed to innocuous levels.

In the two Pacific dumpsites, plutonium-238 and plutonium-239, 240 were found in the sediment at concentrations well above the maximum expected from weapons testing fallout alone. Similar findings were made in the 2800m Atlantic dumpsite for cesium-137. Based upon the data collected up to 1977, the concentrations of radionuclides detected in the sediments at both the Atlantic and Pacific sites do not yet represent a risk either to people or the marine environment.

— If ocean disposal of low-level radioactive wastes were to recommence in the future, the technology exists to survey or monitor a deep ocean site precisely to detect the possible release and movement of selected radionuclides and to recover waste packages disposed at depths up to 2800m.

During July-August 1976, the EPA/ORP's Technology Assessment Division conducted the first comprehensive bottom survey of a disused U.S. radioactive waste dumpsite using the deep submersible ALVIN. A program was successfully completed consisting of sediment coring at precisely located positions both throughout the 100 square mile dumpsite area and relative to specific radioactive waste containers. The cores are being analysed to determine: (a) the extent and direction of radionuclide contamination of the sediments, particularly for cesium-137, (b) the biological infauna populations within the site, and (c) the sediment retention characteristics at the site. In addition, initial results of bottom current measurements indicate the presence of a measurable current with a velocity of sufficient magnitude to transport radioactive materials in solution and adsorbed to sediments. Longer term measurements must be taken to corroborate these findings.

Of particular significance during the 1976 survey was the recovery of an 80 gallon radioactive waste container from a depth of 2800m (9300 feet). Dumped approximately fifteen years ago, the recovered package — which is a container filled with concrete surrounding a smaller container for the waste itself — appears to have withstood the rigors of its immersion surprisingly well. There appears to be limited surface corrosion and the concrete matrix seems to have cured, becoming more durable although still permeable.

Significant progress has been made in the environmental assessment survey programs at both the east and west coast dumpsites. The cumulative results of individual dumpsite surveys will provide the major part of the technical basis for determining the feasibility of ocean disposal of various categories of low-level radioactive wastes in an environmentally acceptable manner. This survey information will also be used in the preparation of a generic Environmental Impact Statement relative to any proposed revisions of the ocean dumping regulations and criteria regarding disposal of such low-level radioactive wastes.

Dose Assessment Program

Since 1975, EPA/ORP has been conducting a nationwide dose assessment program to analyze trends, identify problems and provide support for establishing (and evaluating the implementation of) environmental radiation standards and guides. Major objectives of the program are to:

— determine the status of U.S. environmental radiation data,

— analyze the available data in terms of individual and population doses,

— develop guidance for improving the collection, interpretation and reporting of the data, and

— provide information to guide EPA/ORP.

The general approach of the program is to maximize the use of extensive effluent and environmental monitoring data reported by other State and Federal agencies, including ERDA and NRC, and individual nuclear facilities. These data will be complemented as needed by data acquired from EPA/ORP's Environmental Radiation Ambient Monitoring System (ERAMS), radiation source-related field studies, and dose computational modeling. Only EPA/ORP gathers such a comprehensive data base for radiation dose assessment.

Environmental Radiation Ambient Monitoring System (ERAMS)

ERAMS is an EPA/ORP program for continuing surveillance of radioactivity levels throughout the U.S. and its territories. Over 7,000 individual analyses are performed annually on samples of air, airborne particulates, deposition, surface and drinking water, and milk. After samples are collected by State and local health agencies, they are analyzed at EPA/ORP's Eastern Environmental Radiation Facility (EERF) at Montgomery, Alabama. The present ERAMS emphasis is towards identifying trends in the accumulation of long-lived radionuclides in the environment. Therefore, specific analyses are made for uranium-234, uranium-238, plutonium-239, carbon-14, tritium, strontium-90, and krypton-85. Measurements are also made for gross alpha and beta activity, and the gamma emitters iodine-131, cesium-137, barium-140, and potassium-40.

A quarterly summary of raw ERAMS data (which includes a limited amount of surveillance data from States) is reported in *Environmental Radiation Data.*[3] These quarterlies consist mainly of data tabulations without interpretation or discussion, and are reviewed annually in EPA/ORP's report on the *Radiological Quality of the Environment.* An in-depth analysis of ERAMS is being carried out to determine annual averages, to identify trends, to characterize the statistical distributions of data sets, to estimate individual and population doses, and to evaluate error terms for each of these determinations.

Radiological Quality of the Environment

As part of EPA's dose assessment program, the Office of Radiation Programs initiated an annual evaluation of the radiological quality of the environment. The first report, in 1976, summarized individual and population dose data for both ionizing and nonionizing radiation, with primary emphasis on identifying source categories of ionizing radiation.[3] Sources in that category include ambient environment, technologically enhanced natural radiation, fallout, uranium fuel cycle, Federal facilities, medical, occupational, and others. The nonionizing radiation category is mainly concerned with environmental sources.

Literature searches have been conducted for each of those sources, with data organized to provide: general information about each source category and availability of data, data base description, status of data base analyses, summary of dose data for each source, comparison of reported dose data with estimates from previous publications, and discussion and conclusions.

Table 8.1 summarizes the individual and population doses in the U.S. from each category of radiation source discussed in the report. The information is divided according to the primary mode of exposure: external—which results in a radiation dose to the whole body, or internal—when radioactive materials are inhaled, ingested, or occasionally absorbed through the skin, often resulting in a radiation dose to particular organs of the body.

Population doses from the different source categories can generally be added together to gain a perspective on overall impact. However, doses to individuals vary greatly, so it can be misleading to total individual doses. For this reason, the data show totals only for population doses, not individual doses, in the various source categories.

Facility Data Analysis Project

One object of EPA/ORP's dose assessment program is improving the quality of surveillance data. For this purpose, a facility data analysis project was developed to evaluate the rationale for surveillance programs and to examine their components. Early phases of the project have dealt with criteria for summarizing and using ambient data, development of data analysis techniques, dose conversion criteria, and the development of a manual on sampling methodology.

Information from these initial phases will be used to evaluate surveillance programs at several commercial and Federal nuclear facilities. These reviews will aid in developing criteria for the evaluation of surveillance programs and later will lead to an updating of EPA/ORP's *Environmental Radiation Surveillance Guide.*[4]

Dose Modeling

EPA/ORP continued its ongoing program to develop exposure pathway models for estimating individual and population doses from facility effluents. The emphasis is on long-term population dose commitment and health risks. Two new models were developed in 1976:

— RVDROS,[5] a computer code to calculate population doses from radioactive liquid effluents, and an application to nuclear power reactors on the Mississippi River Basin; and

— AREAC,[6] or Area Source Radiological Emission Analysis Code, to calculate doses from ground level area sources of radon and particulates from tailings piles in the uranium and phosphate industries.

Table 8.1

Summary of dose data from all sources, United States (2)

Source	External		Internal	
	Individual dose (mrem/y)	Population dose (person-rem/y)	Individual dose (mrem/y)	Population dose (person-rem/y)
Ambient ionizing radiation	-	-	-	-
Cosmic radiation	41-45	9.7×10^6	-	-
Ionizing component	28-35	9.2×10^6	-	-
Neutron component	0.33-7	4.9×10^5	-	-
Worldwide radioactivity				
Tritium	-	-	0.04	9.2×10^3
Carbon-14	-	-	1	-
Krypton-85	.035	-	-	-
Terrestrial radiation	30-95	-	18-25	-
Potassium-40	17	-	16	-
Tritium	-	-	4×10^3	-
Carbon-14	-	-	1	-
Rubidium-87	-	-	0.6	-
Uranium 238 series	13	-	2-3	-
Thorium 232 series	25	-	-	-
Technologically enhanced natural radiation	-	-	-	2.73×10^6
Ore mining and milling	-	-	100,000	-
Uranium mill tailings	-	-	[a]140-14000	[b]2.5-70000
Phosphate mining and processing	-	-	-	-
Thorium mining and milling	-	-	-	-
Radon in potable water supplies	-	-	-	-
Radon in natural gas	-	-	[c]54	2.73×10^6
Radon in liquified petroluem gas	-	-	1-4	30000
Radon in mines	-	-	-	-
Radon daughter exposure in natural caves	-	-	14,400	-
Radon and geothermal energy production	-	-	-	-
Radioactivity in construction material	-	-	-	-
Airplane travel				
Jet (cosmic), per trip over Atlantic	2.6	-	-	-
SST (cosmic, per trip over Atlantic	2.0	-	-	-

Table 8.1

Summary of dose data from all sources, United States (2)

Source	External		Internal	
	Individual dose (mrem/y)	Population dose (person-rem/y)	Individual dose (mrem/y)	Population dose (person-rem/y)
Fallout	[d]$\sim$2	-	-	-
Uranium fuel cycle	-	2014	-	-
Mining and milling	-	-	[e]$4.5x10^{-2}$	2.5
Fuel enrichment	[f]<0.1	<0.1	[g]0.3	[h]0.64
Fuel fabrication	-	-	[i]$2x10^{-4}$	[i]0.66
Power reactors BWR	[j]76max	[k]1564	-	-
PWR	[j]4 max	[k]21	-	-
Research reactors	-	-	-	-
Transportation - Nuclear power Industry	-	[m] 100-9600	-	-
Radioisotopes	-	[m]<170	-	-
Reprocessing and spent fuel storage	[n]6	[n]23	[n]14-257	-
Radioactive waste disposal	-	-	-	-
Federal Facilities	-	[t]480	-	-
ERDA	[j]<0.1-358	<1-180	-	-
Department of Defense	<0.01	-	-	-
Accelerators	[j]0.04-4	0.4-65	-	-
Radiopharmaceuticals	-	[o]<0.1	-	[q]$3.3x10^{6}$
Medical radiation				
X radiation	[p]20	-	-	-
Cardiac pacemakers	-	-	<5000	-
Occupational and industrial radiation				
BWR	[r]1230	-	-	-
PWR	[r]1080	-	-	-
All occupations	[s]0.80	-	-	-

Table 8.1

Summary of dose data from all sources, United States (2)

Source	External Individual dose (mrem/y)	External Population dose (person-rem/y)	Internal Individual dose (mrem/y)	Internal Population dose (person-rem/y)
Consumer Products	-	-	-	-
Timepieces	**<0.5	***~6100	-	-
Smoke detectors	^{u}0.007	0.001	-	-
Artificial teeth	-	-	140-1390	-
TV	□ 0.025-0.043			

	Individual exposure ($\mu W/cm^2$)
Nonionizing electromagnetic radiation	
Broadcast towers and airport radars	10
All sources	0.1-1

a Lung dose
b Lung-rem/y
c Trachea-bronchial dose
d 50-year dose commitment divided by 50
e Average individual lung dose within 80 km

f Maximum potential exposure per facility
g Maximum potential exposure
h Cumulative exposure per facility within 80 km radius
i Estimated bone dose within 80 km
j Fence line boundary dose
k Within a radius of 80 km

m Estimated for the year 1973
n For NFS Reprocessing Plant, West Valley, N.Y.

o Based upon data from 5 institutions
p Millirads/y (genetically significant dose)
q Estimated 1980 dose
r Average occupational exposure/y
s Average exposure for all occupations & 3.7 radiation workers/1000 persons in United States
t 1965 data
u Estimated
- = No dose data available
* Maximum individual dose to skin surface
** from digital watches
*** from time pieces containing tritium or radium activated dials
□5cm from TV set; units of mR/h

Radon Daughter Detection

EPA/ORP entered into an Interagency Agreement with the Argonne National Laboratory (an ERDA contractor) to design, develop, and fabricate four systems to detect and evaluate environmental radon daughter levels. They will accurately and rapidly measure the WL and radon daughter concentrations in air, with sensitivity in a range of .001 to 10 WL. The method of measurement will make no assumptions about the radon daughter equilibrium; only constancy of concentrations during the time of sampling (three minutes) will be assumed.

Lifetime Somatic Risk Model

EPA/ORP has developed a model to assess the lifetime somatic effects of radiation exposure as one of a number of competing risks, using a lifetable approach. The model incorporates annual radiation risks into a lifetable framework, and can be used to measure the number of radiation-induced cancer deaths in a population, the reduction in life expectancy caused by radiation exposure, and the average years of life lost to affected individuals.

Effects of Low Level Radiation

ERDA sponsored the bulk of research on this subject, including a project at the Oak Ridge National Laboratory to provide more data on the late effects of low dose rate gamma rays given during the prenatal period. It is hoped that this work (on mice) will help to resolve the scientific controversy over the leukemogenic and carcinogenic effects of low level radiation during fetal life.

On a related subject, the National Cancer Institute funded a Columbia University investigation of various biological effects of low level radiation within the framework of biophysical theory. Some of the effects under scrutiny include carcinogenesis, cell transformation, chromosome aberrations and genetic impairment.

The National Institute of Dental Research began an animal study of possible synergistic effects between repeated low doses of known or suspected chemical carcinogens and of radiation. Designed to improve understanding of the effects on the human mouth, the study should clarify some of the mechanisms involved in the interaction between dual exposures.

ERDA Studies on Bioeffects

ERDA is the major Federal sponsor of research on the biological effects of ionizing radiation, and was involved in projects covering an extremely broad range of related subjects. Below are a few examples, designed to show the variety of the effort rather than represent it fully:

— ERDA continued annual assessment of the 243 Marshallese accidentally exposed to radioactive fallout in 1954. Late effects observed include thyroid abnormalities in 30 of 86 of the most exposed people.

— ERDA kept up U.S. sponsorship of studies of the Japanese atomic bomb victims. Because cancer has been found to be the major delayed effect of their exposure, it has been the main focus of investigation. Studies to detect, explore and characterize changes in risk rates have shown considerable variation over time.

— Funded by ERDA, the University of Utah School of Medicine began compiling a computer-readable, master file of all the data systematically collected on experimental dogs in studies of the toxicity of radionuclides. New data will probably be generated for another fifteen to seventeen years.

— Animal studies were conducted in 1976 at the University of Chicago (with ERDA funds) to identify and measure the harmful effects of radiation during prenatal, postnatal and adult life. Among the factors examined were the age at which sensitivity is greatest, and ways of alleviating or preventing radiation damage.

— To improve estimates of risk to human populations exposed to various types and rates of radiation, ERDA funded a project to study late somatic effects in mammals with a life expectancy between that of lab rodents and people. Experiments with swine and cattle were completed, but burros are still being studied.

— ERDA funded a study by the Argonne National Laboratory to provide basic data for evaluating the hazard to people from exposure to radionuclides deposited within the body. Dose-response information has been collected in relation to differences in both radiation characteristics and species irradiated.

Quality Assurance

Because EPA/ORP's dose assessment program relies heavily on surveillance data reported by other agencies and groups, their validity must be confirmed. EPA/ORP therefore operates a Radiation Quality Assurance Program through its Environmental Monitoring and Support Laboratory in Las Vegas. The two major activities of the program are the distribution of calibrated radionuclide solutions, and laboratory intercomparisons for the analysis of radionuclides in environmental media. This program is available to all Federal, State, local, and private laboratories.

In 1976, EPA and NRC entered into an Interagency Agreement which provides formally for the participation of NRC licensees and their contractor laboratories in the EPA/ORP intercomparison programs. Eventually, NRC will require that all licensees participate in such a quality assurance program.

In 1976, there was considerable interest in the measurement of naturally-occurring radioactive nuclides in various media. To help validate the data from different analyses, the Quality Assurance Branch has added a number of items to its list of calibrated materials, including members of the uranium-235 and -238 series, thorium ore, uranium mill tailings and radium-containing soil. ERDA's Health Services Laboratory in Idaho Falls assisted in the calibration of these materials. Mancos shale from Grand Junction, Colorado, has also been characterized for content of radium-226 and radium-228 by the National Bureau of Standards. All these materials are now available for use by Federal, State, local, and private laboratories for their monitoring and enforcement activities. They are suitable for instrument calibration and standardization, for measurement of chemical yields, and for laboratory internal quality control uses.

Extensive laboratory intercomparison studies involving various environmental media and a number of radionuclides were conducted to help environmental radiation laboratories improve their measurements. Radionuclide concentrations in these studies are generally at or somewhat above current ambient radionuclide concentrations. The kinds of these intercomparison analyses, their frequency, and the number of laboratories participating are presented in Table 8.2.

Because krypton-85 caused increasing concern in 1976, it has been added to the analyses available. It is one of the few fission products released to the environment in fuel reprocessing, and, since it is a noble gas, krypton-85 remains in the atmosphere and has become distributed worldwide, in small but measureable concentrations.

Two reports were issued in 1976 describing activities of the Quality Assurance Program: *Radioactivity Standards Distribution Program, FY 1977,*[7] and *The Status and Quality of Radiation Measurements in Water.*[8]

Table 8.2

ENVIRONMENTAL RADIOACTIVITY INTERCOMPARISON PROGRAM - 1976

Type of cross-check	Number per year	Laboratories participating
Gamma* in water	6	78
Tritium in water	6	81
Nuclides** in milk	6	67
Gross alpha and gross beta in water	6	74
Radium-226 in water	4	38
Nuclides*** on air filters	4	64
Nuclides** in diet	4	25
Tritium in urine	4	15
Krypton-85 in air	3	17

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*^{60}Co, ^{106}Ru, ^{134}Cs, ^{137}Cs, ^{51}Cr, ^{65}Zn

**^{89}Sr, ^{90}Sr, ^{131}I, ^{140}Ba, ^{137}Cs, and ^{40}K

***Gross alpha, gross beta, ^{90}Sr, ^{137}Cs

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4. "Environmental Radiation Surveillance Guide." EPA: ORP/SID 72-2 (1972).

5. Martin, J.A., Jr.; Robbins, C.; Nelson, C.B.; Cousins, R.D., Jr.; and M.A. Culliton. *A Computer Code (RVRDOS) to Calculate Population Doses from Radioactive Liquid Effluents and an Application to Nuclear Power Reactors on the Mississippi River Basin.* EPA: ORP/EAD-76-4 (October 1976).

6. Martin, J.A.; Nelson, C.B.; and P.A. Cuny. *AIREM Program Manual: A Computer Code for Calculating Doses, Population Doses and Ground Depositions Due to Atmospheric Emissions of Radionuclides.* EPA: EPA-520/1-74-004. (May 1974).

7. Ziegler, L.H. *Radioactivity Standards Distribution Program, FY 1977.* EPA: EPA-600/4-76-053 (October 1976).

8. Jarvis, A.N.; Smiecinski, R.F.; and D.G. Easterly. *The Status and Quality of Radiation Measurements of Water.* EPA: EPA-600/4–76–017 (April 1976).

Below are publication numbers for relevant items cited in Appendix B.

EPA Technical Reports: 600/4–75–008

EPA Authored Reports: See Duncan

BRH Technical Publications: FDA 77–8008

APPENDIX A

SUMMARY OF LAWS ENACTED BY STATES DURING 1976

The following is a summary of laws relating to the nuclear regulatory program which were enacted by the States during the 1976 legislative session, compiled by the Nuclear Regulatory Commission.

RADIATION CONTROL

GEORGIA HB-1907. Abolishes the Radiation Control Council and designates the Department of Human Resources as the State radiation control agency. (Signed by Governor 4/7/76)

IOWA HB-1281. Creates an Interagency Coordinating Council on Radiation Safety to develop a State radiation safety program plan. (Signed by Governor 5/13/76)

KENTUCKY HB-499. An amendatory act expanding the functions of the Department of Energy to include development of a process for regulating the siting of energy facilities, and directing the Department of Human Resources to 1) monitor radioactive waste material sites, and 2) "provide for the licensing of the possession or use of any radiation source and the transportation, handling, and disposal of radioactive waste." (Signed by Governor 3/30/76)

MARYLAND HB-1634. Transfers to the Department of Health and Mental Hygiene the radiation control responsibilities formerly vested in the Board of Health. (Signed by Governor 5/17/76)

MISSISSIPPI SB-2229. Establishes a State-wide radiation protection program and designates the State Board of Health as the agency to administer it. (Signed by Governor 5/25/76)

RHODE ISLAND HB-7459. Designates the Department of Health as the State radiation control agency. Creates a State Radiation Advisory Commission as a separate division of the agency. (Signed by Governor 5/28/76)

TENNESSEE HB-1473. Authorizes the Commissioner of Public Health to require certain classes of licensees who use, store or handle radioactive materials to post a performance bond and to contribute to a perpetual care trust fund. (Signed by Governor 3/12/76)

VIRGINIA HB-488. Provides for the posting of bond by certain licensees handling radioactive materials and the creation of a Radioactive Material Perpetual Care Trust Fund into which licensees would make payments on an annual basis. (Signed by Governor 4/10/76)

NUCLEAR STUDIES

CALIFORNIA AB-2820. No new nuclear power plant shall be permitted land use in California until the State Energy Resources Conservation and Development Commission makes a finding that the Federal Government "has identified and approved, and there exists a technology for the construction and operation of, nuclear reprocessing plants." (Signed by Governor 6/3/76)

CALIFORNIA AB-2821. No new nuclear power plant shall be permitted land use in California until the State Energy Commission completes a study of the necessity for and effectiveness and economic feasibility of undergrounding and berm containment of nuclear reactors. (Signed by Governor 6/3/76)

CALIFORNIA AB-2822. No new nuclear power plant shall be permitted land use in California until the State Energy Commission certifies that the Federal Government has approved and there exists a demonstrated technology or means for the disposal of high-level nuclear waste. (Signed by Governor 6/3/76)

IDAHO SCR-132. Authorizes the Legislative Council to appoint a committee to undertake a study of energy development in Idaho. (Adopted 3/18/76)

KENTUCKY HR-100. Directs the Legislative Research Commission to study the effects of radioactive waste disposal in Kentucky and publish its findings by October 1, 1977. (Adopted 3/30/76)

LOUISIANA SCR-18. Directs the Division of Radiation Control to study the facts and circumstances surrounding the construction and use of nuclear reactors within and in proximity of Louisiana and report its findings by 1/18/77. (Signed by Governor 7/30/76)

LOUISIANA SCR-56. Authorizes a Joint Legislative Committee to undertake an indepth study of the feasibility and ramifications of underground salt dome storage of wastes and to report its findings by 3/18/77. (Adopted 7/26/76)

MASSACHUSETTS HB-3161. Extends through 1976 the existence of a special committee of the General Court which was established in 1974 to study the health and safety effects of nuclear power. (Adopted 2/3/76)

PENNSYLVANIA SCR-238. Directs the Joint State Government Commission to study the entire issue of energy facility siting and report its findings, along with draft legislation, to the General Assembly by 5/1/77. (Adopted 6/29/76)

TENNESSEE SJR-162. Directs the legislative Joint Task Force on Energy to continue its study on the use, production and conservation of energy. (Adopted 3/28/76)

ENERGY AGENCIES

CONNECTICUT HB-5825, HB-5897, HB-5898. Amendatory laws expanding the activities and hearing requirements of the Power Facilities Evaluation Council. (Signed by Governor 6/4/76)

GEORGIA HB-1698. Establishes, within the Office of Planning and Budget, the Georgia Office of Energy Resources, which will absorb the functions of the former State Energy Office. (Signed by Governor 4/9/76)

IOWA HB-1371. Extends the life of the Energy Policy Council to June 30, 1979. (Signed by Governor 6/20/76)

NEW YORK SB-9715A. Creates a State Energy Office to administer all energy programs of the Federal Government, other than those conducted by NYSERDA. Abolishes the Atomic Energy

Council and transfers its functions to the new Energy Office. (Signed by Governor 7/26/76)

NEW YORK SB-10719. Creates within the State Energy Office an Energy Advisory Council. (Signed by Governor 7/26/76)

PENNSYLVANIA SB-1219. Establishes within the PUC a Bureau of Conservation, Economics and Energy Planning to conduct energy-related studies and research. (Signed by Governor 7/9/76)

WASHINGTON SB-3172. Creates a State Energy Office to serve as the official State energy responsible for coordination of energy-related activities. Redesignates the Thermal Power Plant Site Evaluation Council as the Energy Facility Site Evaluation Council. (Signed by Governor 3/19/76)

JOINT AGREEMENTS

ARIZONA HB-2340. Authorizes districts to enter into joint agreements for the purpose of acquiring or assuring a supply of energy resources including "uranium and nuclear materials." (Signed by Governor 6/7/76)

COLORADO SB-61. Authorizes Colorado municipalities to contract with municipalities of adjoining States to form power authorities. (Signed by Governor 5/7/76)

VIRGINIA SB-166. Authorizes political subdivisions to join together in the creation of an electric authority for the purposes of providing for energy needs. (Signed by Governor 4/12/76)

WASHINGTON SB-3129. Permits rural electric cooperatives to participate in the development of nuclear and other power facilities. (Signed by Governor 3/4/76)

SITING

CALIFORNIA AB-2820, 2821, 2822. Imposes restrictions on siting. (See Nuclear Studies)

FLORIDA SB-659. The Department of Environmental Regulation is responsible for electric power plant site certifications. Certification by the board, consisting of the Governor and cabinet, constitutes the sole license of the State. (Signed by Governor 6/8/76)

GEORGIA SR-123. Creates a Power Plant Siting Study Committee to "develop proposed legislation to streamline the laws and regulations applicable to power plant siting in this State." (Adopted 1/21/76)

IOWA HB-1470. A single certificate from the Iowa State Commerce Commission is required for the siting and construction of electric power facilities. (Signed by Governor 5/20/76)

KANSAS SB-60. Requires a permit from the State Corporation Commission prior to commencing site preparation and construction of, or addition to, an electric generating facility. (Signed by Governor 3/31/76)

KENTUCKY SR-28. Memorializes the Congress and President to consider very carefully the total impact of nuclear power plant construction on the Ohio River. (Adopted 2/20/76)

KENTUCKY HB-499. The Department of Energy is to develop a process for regulating the siting of energy facilities. (Signed by Governor 3/30/76)

TRANSPORTATION

CONNECTICUT HB-5908. Prohibits the transport of radioactive materials into or through the State without a certificate of transport from the Commissioner of Transportation. (Signed by Governor 6/1/76)

ILLINOIS HB-1815. State Department of Transportation is to develop a legislative program regulating the transportation of hazardous materials through the State. (Signed by Governor 8/26/76)

IOWA HB-736. Requires that the police be notified when an accident occurs involving the transportation of hazardous materials. (Signed by Governor 2/20/76)

MARYLAND HJR-23. State Departments of Transportation, Health and Mental Hygiene and Natural Resources are to formulate recommendations for consolidating into one agency the authority to regulate and supervise the transporting of hazardous materials through Maryland. (Signed by Governor 5/4/76)

NEW YORK AB-7761B. Grants Department of Transportation authority to regulate the transportation of radioactive materials. (Signed by Governor 7/21/76)

DISPOSAL OF NUCLEAR WASTES

CALIFORNIA AB-2822. Energy Commission must certify that there exists a demonstrated technology or means for the disposal of nuclear wastes. (See Nuclear Studies)

HAWAII SR-68. Expresses concern over the disposal of radioactive wastes in the Pacific Ocean 600 miles north of Hawaii. Requests the U.S. Environmental Protection Agency to halt any plans for undersea disposal until their safety is "proven beyond any shadow of doubt." (Adopted 4/5/76)

KENTUCKY HB-838. Levies an excise tax of ten cents per pound to be paid by the processor, on all radioactive waste material delivered to Kentucky for processing, packaging, storage, disposal, or burial. (Signed by Governor 3/30/76)

NEW JERSEY SB-1493. Regulates the disposal of hazardous wastes by prohibiting any solid waste facility within two miles of a river flood hazard area or a major aquifer. (Signed by Governor 10/7/76)

LEGEND

AB — Assembly Bill

HB — House Bill

SB — Senate Bill

HR — House Resolution

HJR — House Joint Resolution

SR — Senate Resolution

HCR — House Concurrent Resolution

SCR — Senate Concurrent Resolution

SJR — Senate Joint Resolution

APPENDIX B

List of Radiation Protection Publications – 1976

EPA PUBLICATIONS

EPA Technical Reports

520/3-75-021	Preliminary Data On The Occurrence of Trans-Uranium Nuclides In The Environment At The Radioactive Waste Burial Site, Maxey Flats, Kentucky
520/3-75-023	Transportation Accident Risks In The Nuclear Power Industry 1975-2000
520/1-76-001	Potential Radiological Impact of Airborne Releases And Direct Gamma Radiation To Individuals Living Near Inactive Uranium Mill Tailings Piles
520/4-76-002	Recommendations On Guidance For Diagnostic X-Ray Studies In Federal Health Care Facilities
520/5-76-003	Radiological Surveillance Studies At The Oyster Creek BWR Nuclear Generating Station
520/7-76-004	Radiation Protection Activities – 1975
520/5-76-005	Radionuclide Accumulation In A Reactor Cooling Lake
520/7-76-007	ORP Program Statement
520/2-76-008	An Examination Of Electric Fields Under EHV Overhead Power Transmission Lines
520/3-76-009	Reactor Safety Study (WASH-1400): A Review Of The Final Report
520/1-76-010	Radiological Quality Of The Environment
520/3-76-011	Significant Actinide And Daughter Activities From The HTGR Fuel Cycle
520/4-76-012	Recommendations On Guidance For Technic To Reduce Unnecessary Exposure From X-Ray Studies In Federal Health Care Facilities
520/4-76-013	Health Effects Of Alpha-Emitting Particles In The Respiratory Tract
520/5-76-014	Radiation Dose Estimates To Phosphate Industry Personnel
520/5-76-015	Air Pathway Exposure Model Validation Study At The Monticello Nuclear Generating Plant

520/4-76-016A	Environmental Radiation Protection Requirements For Normal Operations Of Activities In The Uranium Fuel Cycle, Volume I
520/4-76-016B	Environmental Radiation Protection Requirements For Normal Operations Of Activities In The Uranium Fuel Cycle, Volume II
520/4-76-017	Environmental Analysis Of The Uranium Fuel Cycle
520/4-76-018	A Preliminary Evaluation Of The Control Of Indoor Radon Daughter Levels In New Structures
520/4-76-019	Federal Guidance Report No. 9: Radiation Protection Guidance For Diagnostic X-Rays
520/5-76/020	Radiological Measurement At The Maxey Flats Radioactive Waste Burial Site – 1974 to 1975
600/4-76-027	Radioactive Prediction Model for Nuclear Tests
600/4-76-035	Factors Affecting the Use of CaF_2:Mn Thermoluminescent Dosimeters for Low-Level Environmental Radiation Monitoring

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ORP/CSD 76–1	A Statistical Analysis Of The Projected Performance Of Multi-Unit Reactor Sites
ORP/CSD 76–2	Estimate of the Cancer Risk Due to Nuclear-Electric Power Generation
ORP/EAD 76–1	Radiation Characteristics Of Traffic Radar Systems
ORP/EAD 76–2	A Measurement Of RF Field Intensities In The Vicinity Of An FM Broadcast Station Antenna

ORP/EAD 76-3	Radioactive Isotopic Characterization of the Environment Near Wiscasset, Maine Using Pre and Post-Operational Surveys in the Vicinity of the Maine Yankee Nuclear Reactor
ORP/EAD 76-4	A Computer Code (RVRDOS) to Calculate Population Doses from Radioactive Liquid Effluents and an Application to Nuclear Power Reactors on the Mississippi River Basin
ORP/EAD 76-6	Area Source Radiological Emission Analysis Code (AREAC)
ORP/LV 75-8A	Radioactivity Associated with Geothermal Waters in the Western United States—Basic Data
ORP/LV 76-1	Radiation Survey in Beatty, Nevada, And Surrounding Area
ORP/LV 76-2	Parameters For Estimating The Uptake Of Transuranic Elements By Terrestrial Plants
ORP/LV 76-3	Review Of State Licenses For Disposal Of Low-Level Radioactive Waste By Shallow Land Burial
ORP/LV 76-4	Report Of Ambient Outdoor Radon And Indoor Radon Progeny Concentrations During November 1975 At Selected Locations In The Grants Mineral Belt, New Mexico
ORP/LV 76-5	Evaluation Of Sample Collection And Analysis Techniques For Environmental Plutonium
ORP/LV 76-7	Environmental And Safety Aspects Of Alternative Nuclear Power Technologies Fusion Power Systems
ORP/LV 76-9	Sampling and Data Reporting Considerations for Airborne Particulate Radioactivity
ORP/TAD 76-1	Determination Of Radium Removal Efficiencies In Iowa Water Supply Treatment Processes
ORP/TAD 76-2	Determination Of Radium Removal Efficiencies In Illinois Water Supply Treatment Processes For Small And Large Populations
ORP/TAD 76-3	Public Health Considerations Of Carbon-14 Discharges From The Light-Water-Cooled Nuclear Power Reactor Industry
ORP/TAD 76-4	Available Methods Of Solidification For Low-Level Radioactive Wastes In The United States
ORP/TAD 76-5	Determination Of Radium Removal Efficiency In Water Treatment Processess

Environmental Radiation Data
EPA, Eastern Environmental Radiation Facility
Montgomery, Alabama 36109

Report 5	July 1976 (January, February and March Data)
Report 6	October 1976 (April, May and June Data)
Report 7	January 1977 (July, August and September Data)
Report 8	April 1977 (October, November and December Data)

BRH TECHNICAL PUBLICATIONS

FDA 76-8024	BRH Publications Index (PB 251 240/AS, $9.00)
FDA 76-8025	The Clinical Testing of Male Gonad Shields (PB 250 753/AS, $4.00)
FDA 76-8026	Seventh Annual National Conference on Radiation Control – Assuring Protection (GPO 017-015-00097-4, $4.40) (PB 251 344/AS, mf only)
FDA 76-8027	The Use of Electron Linear Accelerators in Medical Radiation Therapy: Physical Characteristics (GPO 017-015-00098-2, $1.75) (PB 253 605/AS, $5.50)
FDA 76-8028	BRH Routine Compliance Testing for Cabinet X-Ray Systems (PB 253 916/AS, $4.50)
FDA 76-8029	Tabulated Values of Accessible Emission Limits for Laser Products (PB 254 254/AS, $4.50)
FDA 76-8030	Organ Doses in Diagnostic Radiology (GPO 017-015-00102-4, $1.95) (PB 255 363/AS, mf only)
FDA 76-8031	Handbook of Selected Organ Doses for Projections Common in Diagnostic Radiology (GPO 017-015-00109-1, $0.75) (PB 257 482/AS, mf only)
FDA 76-8033	Applications of Iodine in Nuclear Medicine – Proceedings of a Conference (GPO 017-015-00091-1, $2.10) (PB 254 223/AS, mf only)
FDA 76-8034	Gonad Doses and Genetically Significant Dose from Diagnostic Radiology: U.S., 1964 and 1970 (GPO 017-015-00100-8, $1.30) (PB 254 173/AS, mf only)
FDA 76-8035	Regulations for the Administration and Enforcement of the Radiation Control for Health and Safety Act of 1968 (GPO 017-012-00233-1, $0.90)
FDA 76-8036	Quality Control Practices for Compliance with the Federal Laser Product Performance Standard (PB 254 249/AS, $4.00)

FDA 76–8037	National Conference on Measurements of Laser Emissions for Regulatory Purposes
FDA 76–8039	Workshop Manual for Quality Control of Scintillation Cameras in Nuclear Medicine (GPO 017–015–00104–1, $1.55) (PB 255 362/AS, mf only)
FDA 76–8040	Laser Products—Federal Requirements for Manufacturers (GPO 017–015–00101–6, $0.35)
FDA 76–8042	Dental Exposure Normalization Technique "DENT" Instruction Manual (PB 256 678/AS, $4.50)
FDA 76–8043	Photographic Quality Assurance in Diagnostic Radiology, Nuclear Medicine, and Radiation Therapy (GPO 017–015–00107–5, $1.75) (PB 255 973/AS, mf only)
FDA 76–8044	Radiopharmaceutical Dosimetry Symposium (GPO 017–015–00108-3, $6.20) (PB 257 572/AS, mf only)
FDA 76–8045	A Pilot Study of Nuclear Medicine Through the Medically Oriented Date System (GPO 017–015–00106–7, $0.75) (PB 256 029/AS, mf only)
FDA 76–8046	Quality Control for Scintillation Cameras (GPO 017–015–00105–9, $1.15) (PB 255 892/AS, mf only)
FDA 76–8048	Radiation Protection During Medical X-Ray Examinations – Part 4, Biological Effects of X Rays (National Audiovisual Center (GSA), Washington, D.C. 20409, $48.00)
FDA 76–8049	Radiation Protection During Medical X-Ray Examinations – Part 5, Gonad Shielding in Diagnostic Radiology (National Audiovisual Center (GSA), Washington, D.C. 20409, $39.00)
FDA 76–8051	Directory of Personnel Responsible for Radiological Health Programs
FDA 76–8052	Nationwide Evaluation of X-Ray Trends (GPO 017–015–00110–5, $0.35)
FDA 76–8054	Specific Area Gonad Shielding – Recommendation for Use on Patients During Diagnostic X-Ray Procedures (GPO 017–015–00111-3, $0.45) (PB 258 039/AS, mf only)
FDA 76–8055	Diagnostic Ultrasound: A Review of Clinical Applications and the State of the Art of Commerical and Experimental Systems (GPO 017–015–00112–1, $1.45) (PB 258 237/AS, mf only)
FDA 76–8056	CSU-FDA Collaborative Radiological Health Laboratory Annual Report 1975 (PB 257 937/AS, $6.75, $3.00 mf)
FDA 76–8058	Quadrennial Report of the Division of Biological Effects (PB 258 436/AS $6.75)
FDA 76–8061	Uranium in.Dental Porcelain (GPO 017–015–00113–0, $1.00)
FDA 77–8001	BRH Routine Compliance Testing for Diagnostic X-Ray Systems

FDA 77–8002 Symposium on Biological Effects and Measurement of Light Sources (GPO 017–015–000114–8, $3.30)

FDA 77–8003 First Image Recepter Conference: Film/Screen Combinations (GPO 017–015–000115–6, $2.50)

FDA 77–8004 Biological Effects of Ionizing Radiation: An Overview

FDA 77–8005 Report of State and Local Radiological Health Programs, Fiscal Year 1975 (PB 259 947/AS, $4.50)

FDA 77–8006 Nationwide Evaluation of X-Ray Trends: Organ Dose Index System-Instruction Manual

FDA 77–8007 Radiation Safety Handbook for Ionizing & Nonionizing Radiation (GPO 017–015–00116–4, $1.70) (PB 262 109/AS, mf only)

FDA 77–8008 Imports – Radiation-Producing Electronic Products

FDA 77–8009 Comparison of Radiation Exposures from Panoramic Dental X-Ray Units

FDA 77–8010 Biological Effects of Electromagnetic Waves – Selected Papers of the USNC/URSI Annual Meeting – Volume 1

FDA 77–8011 Biological Effects of Electromagnetic Waves – Selected Papers of the USNC/URSI Annual Meeting – Volume 2

1976 Annual Report Administration of the Radiation Control for Health and Safety Act of 1968 Public Law 90–602 April 1, 1977

ERDA PUBLICATIONS

ERDA Technical Reports

ERDA-76–29 ENVIRONMENTAL RESEARCH AND THE ERDA FOSSIL ENERGY RESEARCH CENTERS: A RECOMMENDED COMPLEMENTARY PROGRAM. (Interim Report.) Oct. 1975 NTIS $7.50 AES/Div. of Biomedical & Environmental Research (Prepared by Greenfield, Attaway & Tyler, Inc.)

ERDA-76–43 ALTERNATIVES FOR MANAGING WASTES FROM REACTORS AND POST-FISSION OPERATIONS IN THE LWR FUEL CYCLE. Vol. 1 – Summary $7.50; Vol. 2 – Alternatives for Waste Treatment $12.75; Vol. 3 – Alternatives for Interim Storage and Transportation $9.00; Vol. 4 – Alternatives for Waste Isolation and Disposal $8.00; Vol. 5 – Appendices $9.25; May 1976 NTIS, H. Soule, 353-3253 ANE/Div. of Nuclear Fuel Cycle & Production

ERDA-76–45–1 OCCUPANCY USE READINESS MANUAL: SAFETY CONSIDERATIONS. (SSDC-1) Apr. 1976 NTIS $4.00 R. Eicher, 353–5601

ERDA-76–45–2	HUMAN FACTORS IN DESIGN. (SSDC-2) Feb. 1976 NTIS $6.00
ERDA-76–45–7	ERDA GUIDE TO THE CLASSIFICATION OF OCCUPATIONAL INJURIES AND ILLNESSES. (SSDC-7) Oct. 1976 NTIS $4.00
ERDA-76–70	SURVEY OF SUPRESSION OF SODIUM FIRES IN LIQUID METAL FAST BREEDER REACTORS. June 1976 NTIS $3.50 A. Weintraub, 353-5610 AES/Div. of Safety, Standards, and Compliance (Prepared by Factory Mutual Research Corp., Norwood, Mass.)
ERDA-76–73	ERDA FIELD ORGANIZATION: CAPSULE SUMMARIES OF PLANTS AND LABORATORIES, FY 1975. Aug. 1976 NTIS $4.00 V. Garber, 376-9132 A/A for Field Operations
ERDA-76–83	PROGRAMS OF THE MATERIALS & RADIATION EFFECTS BRANCH, DIVISION OF MAGNETIC FUSION ENERGY. June 1976 NTIS $5.50 E. Dalder, 353–4964 ASGA/Div. of Magnetic Fusion Energy
ERDA-76–89	LIVING WITH RADIATION: The Problems of the Nuclear Age for the Layman. July 1976 NTIS $4.50 K. Hoag, 353–5602 AES/Div. of Safety, Standards, and Compliance (Prepared by Francis L. Bannigan)
ERDA-76–101	RADIATION PROTECTION ENROLLMENTS AND DEGREES, 1975. (5th ed.) Enrollments, Fall 1975. Degrees Granted, July 1965-June 1975. Sep. 1976 NTIS $4.50 L. Barker, 376–9180 AIR/Office of University Programs (Prepared by the Manpower Development Div., ORAU)
ERDA-76–104	ENVIRONMENTAL MONITORING AT MAJOR U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION CONTRACTOR SITES. CALENDAR YEAR 1975. (2 vols.) Aug. 1976 NTIS $18.75 each D. Elle, 353-5622 AES/Div. of Safety, Standards, and Compliance
ERDA-76–107	ADVANCED NUCLEAR REACTORS: AN INTRODUCTION. May 1976 NTIS $4.00 S. Wells, 353–5407 ANE/Div. of Reactor Development & Demonstration
ERDA-76–111	EMPLOYMENT IN NUCLEAR ENERGY ACTIVITIES, 1975: A Highlights Report. Oct. 1976 GPO $0.65 L. Barker, 376–9180 AIR/Office of University Programs
ERDA-76–119	SEVENTH ANNUAL REPORT OF RADIATION EXPOSURES FOR AEC AND AEC-CONTRACTOR EMPLOYEES – 1974. Oct. 1976 NTIS $4.00 K. Baker, 353–5615 AES/Div. of Safety, Standards, and Compliance
ERDA-76–121	BENEFIT ANALYSIS OF REPROCESSING AND RECYCLING LIGHT WATER REACTOR FUEL. Dec. 1976 NTIS $4.00 J. Thereault, 353–4265 ANE/Div. of Nuclear Fuel Cycle & Production
ERDA-76–122	MASTER PLAN – DIVISION OF SAFEGUARDS AND SECURITY. Sept. 1976 NTIS $6.00 J. Hennessey, 353–5697 ANS/Div. of Safeguards & Security
ERDA-76–134	WORKSHOP ON ENVIRONMENTAL RESEARCH FOR TRANSURANIC ELEMENTS. Proceedings of the Workshop, Nov. 12–14, 1975. Battelle Seattle Research Center,

	Seattle, Washington. Nov. 1976 NTIS $4.50 W. Forster, 353–5323 AES/Div. of Biomedical & Environmental Research
ERDA-76–135	NUCLEAR MEDICINE RESEARCH: AN EVALUATION OF THE ERDA PROGRAM. Aug. 1976 NTIS $4.00 W. Weyzen, 353–5355 AES/Div. of Biomedical & Environmental Research
ERDA-76–162	THE MANAGEMENT AND STORAGE OF COMMERCIAL POWER REACTOR WASTES. A Summary Based on the ERDA Technical Alternatives Document (ERDA-76–43). Dec. 1976 F. Tooper, 353–5458 ANE/Div. of Wastes Mgmt, Production, & Reprocessing

NRC PUBLICATIONS

NUREG-0002.	Final Generic Environmental Statement on the Use of Mixed Oxide Fuel in Light Water Cooled Reactors – Health, Safety and Environment. Office of Nuclear Material Safety and Safeguards. Aug. 1976 1,761 pp. NTIS (Springfield, Va. 22161) $47.00 for set
NUREG-0015.	Security Agency Study: Report to the Congress on the Need for, and the Feasibility of, Establishing a Security Agency within the Office of Nuclear Material Safety and Safeguards. Office of Nuclear Material Safety and Safeguards. Aug. 1976 156 pp. NTIS $6.75
NUREG-0016.	Calculations of Releases of Radioactive Materials in Gaseous and Liquid Effluents for Boiling Water Reactors (BWR-TALE Code). Office of Standards Development (Siting, Health and Safeguards Standards). April 1976 140 pp. NTIS $6.00
NUREG-0017.	Calculations of Releases of Radioactive Materials in Gaseous and Liquid Effluents for Pressurized Water Reactors (PWR-GALE Code). Office of Standards Development (Siting, Health and Safeguards Standards). April 1976 148 pp. NTIS $6.00
NUREG-0025.	Monthly Inspection Summary Report. Office of Management Information and Program Control. Monthly NTIS $35/y
NUREG-0026.	Evaluation of Soil Liquefaction Potential for Level Ground During Earthquakes – A Summary Report. Prepared for USNRC Office of Nuclear Regulatory Research (Safeguards, Fuel Cycle and Environmental Research) by Shannon & Wilson, Inc., and Agbabian Associates. Contract AT(04–3)-954. Aug. 1976 128 pp. NTIS $6.00
NUREG-0027.	Determination of Soil Liquefaction Characteristics by Large-Scale Laboratory Tests. Prepared for USNRC Office of Nuclear Regulatory Research (Safeguards, Fuel Cycle and Environmental Research) by Shannon & Wilson, Inc., and Agbabian Associates. Contract AT(04–3)-954. Aug. 1976 172 pp. NTIS $6.75
NUREG-0028.	In Situ Impulse Test – An Experimental and Analytical Evaluation of Data Interpretation Procedures. Prepared for USNRC Office of Nuclear Regulatory Research (Safeguards, Fuel Cycle and Environmental Research) by Shannon &

Wilson, Inc., and Agbabian Associates. Contract AT(04–3)-954. Aug. 1976 292 pp. NTIS $9.25

NUREG-0029, Vol. 1. Geotechnical and Strong Motion Earthquake Data from U.S. Accelerograph Stations: Ferndale, Cholame and El Centro, California. Prepared for USNRC Office of Nuclear Regulatory Research (Safeguards, Fuel Cycle and Environmental Research) by Shannon & Wilson, Inc., and Agbabian Associates. Contract AT(04–3)-954. Aug. 1976 340 pp. NTIS $10.00

NUREG-0030. Construction Status of Nuclear Power Plants. (Yellow Book) Office of Management Information and Program Control. Monthly NTIS $100/y. $10/copy

NUREG-0034. (Docket PR-71, 73) Draft Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes. Office of Standards Development (Engineering Standards). March 1976 384 pp

NUREG-0041. Manual of Respiratory Protection Against Airborne Radioactive Materials. Caplin, J.L.; Held, B.J.; and R.J. Catlin. Office of Standards Development (Siting, Health and Safeguards Standards). Sept. 1976 152 pp. NTIS $6.75

NUREG-0043. Alternative Processes for Managing Existing Commercial High-Level Radioactive Wastes. Office of Nuclear Material Safety and Safeguards (Fuel Cycle and Material Safety). April 1976 184 pp. NTIS $7.50

NUREG-0050. Recommendation Related to Browns Ferry Fire. Hanauer, S.H., *et al.*, Special Review Group. Feb. 1976 86 pp. NTIS $5.00

NUREG-0054 (Supp. 1 to NUREG-75/100). (Docket SIN 50–437) Supplement 1 to the Safety Evaluation Report for the Offshore Systems Floating Nuclear Plants. Office of Nuclear Reactor Regulation (Project Management). March 1976 47 pp. NTIS $4.00

NUREG-0056, Vol. 1. (Docket SIN 50–437) Final Environmental Statement on Floating Nuclear Power Plant, Vol. 1. Office of Nuclear Reactor Regulation (Site Safety and Environmental Analysis). Sept. 1976 708 pp. NTIS $16.25

NUREG-0060. Final Generic Environmental Statement on the Routine Use of Plutonium Powered Cardiac Pace Makers. Office of Nuclear Material Safety and Safeguards (Fuel Cycle and Material Safety). July 1976 284 pp. NTIS $9.25

NUREG-0061 (Supp. 1). (Docket 50–259/50–260) Supplement 1 to the Safety Evaluation Report for Operations of Browns Ferry, Units 1 and 2, Following the March 22, 1975 Fire. Office of Nuclear Reactor Regulation (Operating Reactors). July 1976 88 pp. NTIS $5.00

NUREG-0069. Potential Releases of Cesium from Irradiated Fuel in a Transportation Accident. Office of Standards Development (Engineering Standards). July 1976 24 pp. NTIS $3.50

NUREG-0073. Transport of Radioactive Material in the U.S.: A Detailed Summary of "Survey of Radioactive Material Shipment in the United States," BNWL-1972. Office of Standards Development (Engineering Standards). May 1976 20 pp. Avail. at NRC

NUREG-0074. (Docket PRM 40–19) Draft Environmental Statement on Proposed Rule-Making Exemption from Licensing Requirements for Personnel Neutron Dosimeters that Contain Natural Thorium. Office of Standards Development (Engineering Standards). June 1976 72 pp. Avail. at NRC

NUREG-0077. Radioactive Material Released from Nuclear Power Plants: 1974. Office of Management Information and Program Control. June 1976 120 pp. NTIS $5.50

NUREG-0090–1. Report to Congress on Abnormal Occurrences: July – September 1975. Office of Information Management and Program Control. March 1976 20 pp. NTIS $3.50

NUREG-0090–2. Report to Congress on Abnormal Occurrences: October – December 1975. Office of Information Management and Program Control. March 1976 16 pp. NTIS $3.50

NUREG-0090–3. Report to Congress on Abnormal Occurrences: January – March 1976. Office of Management Information and Program Control. July 1976 24 pp. NTIS $3.50

NUREG-0090–4. Report to Congress on Abnormal Occurrences: April – June 1976. Office of Management Information and Program Control. Oct. 1976 16 pp. NTIS $3.50

NUREG-0093–1. Radiological Emergency Response Planning Handbook of Federal Assistance to State and Local Governments. Office of State Programs. June 1976 80 pp. NTIS $5.00

NUREG-0099. Preparation of Environmental Reports for Nuclear Power Stations. (Regulatory Guide 4.2, Rev. 2). Office of Standards Development. July 1976 100 pp. NTIS $5.00

NUREG-0109. Occupational Radiation Exposure at Light Water Cooled Reactors – 1969–1975. Murphy, T.D., *et al.* Office of Nuclear Reactor Regulation (Site Safety and Environmental Analysis). Aug. 1976 24 pp. NTIS $3.50

NUREG-0116. (Supp. I to WASH-1248). Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle. Office of Nuclear Material Safety and Safeguards (Fuel Cycle and Material Safety). Oct. 1976 304 pp. NTIS $9.75

NUREG-0119. Eighth Annual Occupational Radiation Exposure Report for 1975. Office of Management Information and Program Control. Oct. 1976 32 pp. NTIS $4.00

NRC Regulatory Guides

1.64 (Rev. 2) Quality Assurance Requirements for the Design of Nuclear Power Plants, July 1976

1.98 Assumptions Used for Evaluating the Potential Radiological Consequences of a Radioactive Offgas System Failure in a Boiling Water Reactor, March 1976

1.102 (Rev. 1) Flood Protection for Nuclear Power Plants, September 1976

1.109 Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix 1, March 1976

1.110 Cost-Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Power Reactors, March 1976

1.111 Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors, March 1976

1.112 Calculations of Releases of Radioactive Material in Gaseous and Liquid Effluents from Light-Water-Cooled Power Reactors, May 1976

1.113 Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix 1, May 1976

1.120 Fire Protection Guidelines for Nuclear Power Plants, June 1976

3.38 General Fire Protection Guide for Fuel Reprocessing Plants, June 1976

4.13 Performance, Testing and Procedural Specifications for Thermoluminescence Dosimetry: Environmental Applications, November 1976

5.57 Shipping and Receiving Control of Special Nuclear Material, July 1976

6.7 (Rev. 1) Preparation of an Environmental Report to Support a Rule Making Petition Seeking an Exemption for a Radionuclide-Containing Product, June 1976

8.14 Personnel Neutron Dosimeters, June 1976

8.15 Acceptable Programs for Respiratory Protection, October 1976

WHERE TO WRITE FOR INFORMATION

Publications with a GPO number may be ordered from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402; those with an NTIS number may be ordered from the National Technical Information Service, Springfield, Va. 22161. Some, as noted, are available in microfilm or microfiche (mf). Publications with neither a GPO nor an NTIS number may be ordered directly from the agencies which publish them, at the addresses below:

Bureau of Radiological Health
BRH Technical Information
5600 Fishers Lane
Rockville, Maryland 20857

Energy Research and Development Administration
Office of Public Affairs
ERDA
Room 7110
20 Mass. Ave., NW
Washington, D.C. 20545

Environmental Protection Agency
Office of Radiation Programs
(AW-460)
401 M Street, SW
Washington, D.C. 20460

Nuclear Regulatory Commission
Document Control
Washington, D.C. 20555

C.1

APPENDIX C

NON-GOVERNMENT STANDARDS SETTING BODIES

American National Standards Institute (ANSI)

ANSI acts as a clearinghouse to coordinate standards development in the private sector by about 20 pertinent professional and technical societies. The actual drafting of standards is done by experts sitting on society sponsored panels. Since 1975, the responsibility of the ANSI Secretariat for the Main Committee on Radiation Protection has been assumed by the Health Physics Society (see below).

There are presently twelve ANSI Standards in force. These include standards for administrative practices in radiation monitoring, specification of standards source terms for nuclear power plants for environmental dose design calculations, guides for radiation protection in uranium mines, air sampling criteria, and performance specifications for instrumentation. Copies of these Standards are available from the American National Standards Institute, 1430 Broadway, New York, New York 10018.

In addition, about twenty other standards are in various stages of development. These include standards on performance specifications for thermoluminescent dosimeters, monitoring of occupational exposure, several standards in the field of environmental contamination, and others dealing with contamination of equipment and facilities. A series of standards is also underway dealing with environmental radiation surveillance. Finally, a number of standards on internal dosimetry techniques are being prepared with respect to occupational exposures to activation and fission products, tritium, uranium, and plutonium. For further information, see M.E. Wrenn's paper "The U.S. National Voluntary Concensus Nuclear Standards Program in Radiation Protection (ANSI N-13)," presented at the International Radiation Protection Association, Paris, April 24–30, 1977.

National Council on Radiation Protection & Measurements (NCRP)

Four new reports were published during 1976:

Tritium Measurement Techniques (Report No. 47): provided information on methods for measuring tritium in a variety of media, and on selecting procedures best suited to particular problems and situations; describes the most important measurement methods and their advantages and disadvantages; includes an extensive bibliography.

Radiation Protection for Medical and Allied Health Personnel (Report No. 48): discusses biological considerations, the x-ray department, radioactive nuclides, laboratories, the morgue, disposal of radioactive waste, all directed at individuals who use radiation in healing arts. Also includes appendices on special topics such as maximum permissible doses and dose limits, radiation detecting devices, and caution signs.

Structural Shielding Design and Evaluation for Medical Use of X-Rays and Gamma Rays of Energies Up to 10 MeV (Report No. 49): discusses factors to consider in selection of appropriate shielding materials and in calculation of barrier thickness, superceding the 1970 recommendations; explicitly gives specific values of the parameters used in the formulation of tables.

Environmental Radiation Measurement (Report No. 50): presents sampling and sample analysis for radioactivity, information on properties of widely distributed radionuclides and typical radiation fields in the environment; treats methods for measurement, including evaluation of available and developing methods; identifies areas where present knowledge is limited.

Health Physics Society

Major Standards Committee activities on formulating new standards in 1976 were as follows:

— Performance Testing and Procedural Specifications for Thermoluminescense Dosimetry: Environmental Applications (ANSI N-545) — final version published.

— American National Standard for Personnel Neutron Dosimeters (Neutron Energies Less than 20 MeV) — published.

— Criteria for Testing Personnel Dosimetry Performance — now being prepared for a letter ballot.

— Radiation Instrumentation Test and Calibration (ANSI N-323) — currently in final processing.

— Internal Dosimetry Techniques for Uranium — in preparation for ANSI N-13 letter ballot.

— Internal Dosimetry Techniques for Fission and Activation Products (ANSI N-343) — now being balloted.

— Criteria for Maintaining Exposures As Low As Practicable — first draft in preparation.

— Control of Radioactive Surface Contamination on Materials Equipment and Facilities to be Released for Uncontrolled Use — approved by ANSI N-13 and transmitted to the ANSI Board of Standards Review for final processing.

— Standards for the Unconditional Release of Real Property (ANSI N-547) — committee being constituted.

The Standards Committee established an International Division, which began focussing on the pending Gatt Standards Code. Among other things, the draft Code requires that no technical barriers to trade be created by mandatory central government standards, test methods, and certification procedures (covering industrial and agricultural products, and packaging and labeling regulations relating to products). The Code also calls for notification and consultation in developing standards and equal treatment of domestic and foreign products with respect to standards adopted.

International Commission on Radiological Units & Measurements

At its 1976 annual meeting, the Commission decided to publish the following reports:

— An International Neutron Dosimetry Intercomparison

— Assessment of Absorbed Dose in Clinical Use of Radionuclides

— Basic Aspects of High Energy Particle Interactions and Radiation Dosimetry.

Progress was reviewed in a wide variety of fields, including the average energy required to produce an ion pair, dose specifications for reporting, dosimetry of pulsed radiation, fundamental quantities and units, photographic dosimetry in external beam therapy, and radiobiological dosimetry. In addition to approving development of a new report emphasizing clinical aspects of electron beam dosimetry, the Commission approved a report committee to work on low level *in vivo* counting in humans.

The Commission and the International Commission on Radiation Protection (ICRP) collaborated in discussing specific names for the International System (SI) units of the quantities of absorbed dose and activity.

Others

Other private organizations which have set standards bearing on radiation protection in 1976 are the American Nuclear Society, the American Society for Testing and Materials, the American Society of Mechanical Engineers, the Institute of Electrical and Electronics Engineers, the American Institute of Chemical Engineers, the Institute of Nuclear Materials Management, the National Fire Protection Association, and Underwriters Laboratories.

APPENDIX D

Charts of Organization

Figure 1 Summary Diagram of Major Federal Radiation Protection Functions

Figure 2 Environmental Protection Agency

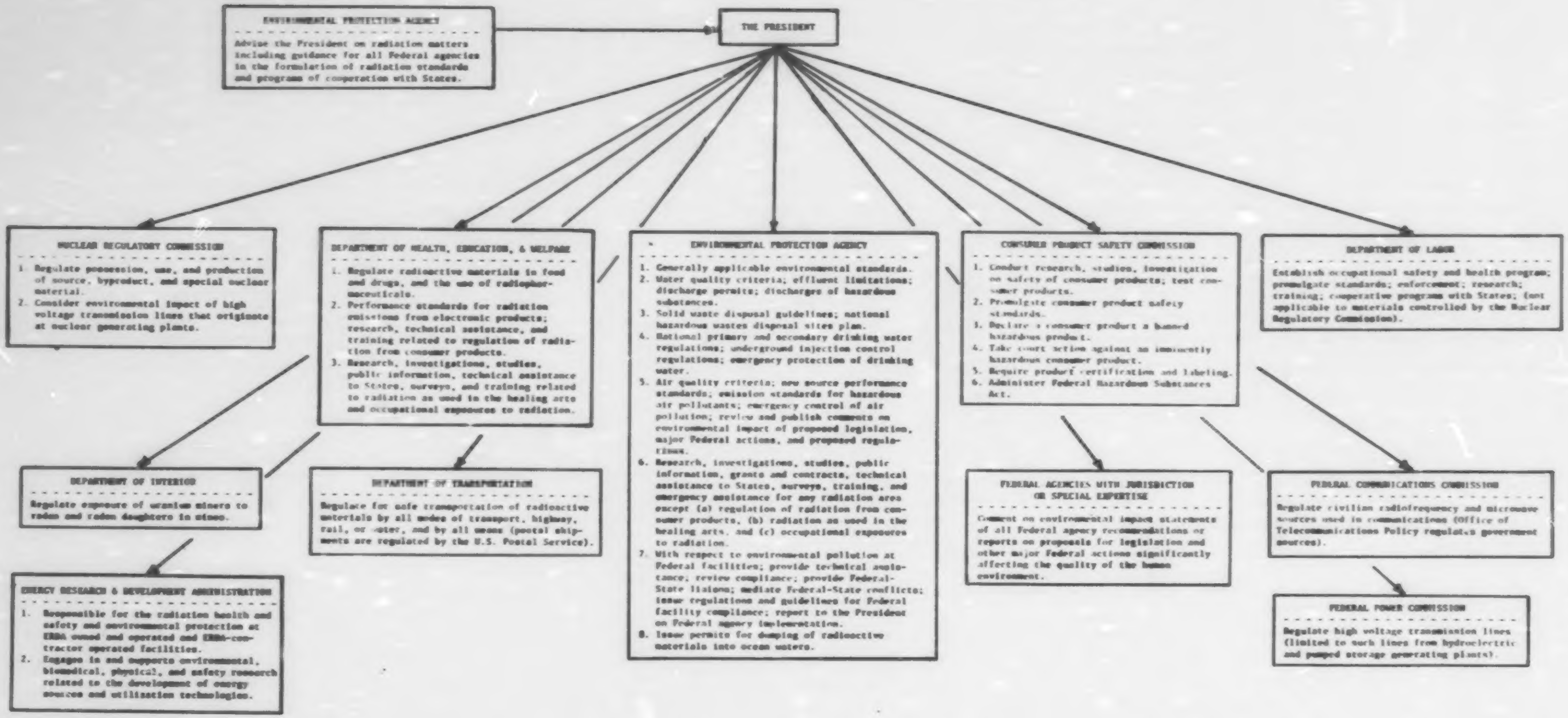
Figure 3 Energy Research and Development Administration

Figure 4 Bureau of Radiological Health

Figure 5 Nuclear Regulatory Commission

D 2

SUMMARY DIAGRAM OF MAJOR FEDERAL RADIATION PROTECTION FUNCTIONS



ENVIRONMENTAL PROTECTION AGENCY

Advise the President on radiation matters including guidance for all Federal agencies in the formulation of radiation standards and programs of cooperation with States.

THE PRESIDENT

NUCLEAR REGULATORY COMMISSION

1. Regulate possession, use, and production of source, byproduct, and special nuclear material.
2. Consider environmental impact of high voltage transmission lines that originate at nuclear generating plants.

DEPARTMENT OF HEALTH, EDUCATION, & WELFARE

1. Regulate radioactive materials in food and drugs, and the use of radiopharmaceuticals.
2. Performance standards for radiation emissions from electronic products; research, technical assistance, and training related to regulation of radiation from consumer products.
3. Research, investigations, studies, public information, technical assistance to States, surveys, and training related to radiation as used in the healing arts and occupational exposures to radiation.

ENVIRONMENTAL PROTECTION AGENCY

1. Generally applicable environmental standards.
2. Water quality criteria; effluent limitations; discharge permits; discharges of hazardous substances.
3. Solid waste disposal guidelines; national hazardous wastes disposal sites plan.
4. National primary and secondary drinking water regulations; underground injection control regulations; emergency protection of drinking water.
5. Air quality criteria; new source performance standards; emission standards for hazardous air pollutants; emergency control of air pollution; review and publish comments on environmental impact of proposed legislation, major Federal actions, and proposed regulations.
6. Research, investigations, studies, public information, grants and contracts, technical assistance to States, surveys, training, and emergency assistance for any radiation area except (a) regulation of radiation from consumer products, (b) radiation as used in the healing arts, and (c) occupational exposures to radiation.
7. With respect to environmental pollution at Federal facilities; provide technical assistance; review compliance; provide Federal-State liaison; mediate Federal-State conflicts; issue regulations and guidelines for Federal facility compliance; report to the President on Federal agency implementation.
8. Issue permits for dumping of radioactive materials into ocean waters.

CONSUMER PRODUCT SAFETY COMMISSION

1. Conduct research, studies, investigation on safety of consumer products; test consumer products.
2. Promulgate consumer product safety standards.
3. Declare a consumer product a banned hazardous product.
4. Take court action against an imminently hazardous consumer product.
5. Require product certification and labeling.
6. Administer Federal Hazardous Substances Act.

DEPARTMENT OF LABOR

Establish occupational safety and health program; promulgate standards; enforcement; research; training; cooperative programs with States; (not applicable to materials controlled by the Nuclear Regulatory Commission).

DEPARTMENT OF INTERIOR

Regulate exposure of uranium miners to radon and radon daughters in mines.

DEPARTMENT OF TRANSPORTATION

Regulate for safe transportation of radioactive materials by all modes of transport, highway, rail, or water, and by all means (postal shipments are regulated by the U.S. Postal Service).

FEDERAL AGENCIES WITH JURISDICTION OR SPECIAL EXPERTISE

Comment on environmental impact statements of all Federal agency recommendations or reports on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment.

FEDERAL COMMUNICATIONS COMMISSION

Regulate civilian radiofrequency and microwave sources used in communications (Office of Telecommunications Policy regulates government sources).

ENERGY RESEARCH & DEVELOPMENT ADMINISTRATION

1. Responsible for the radiation health and safety and environmental protection at ERDA owned and operated and ERDA-contractor operated facilities.
2. Engages in and supports environmental, biomedical, physical, and safety research related to the development of energy sources and utilization technologies.

FEDERAL POWER COMMISSION

Regulate high voltage transmission lines (limited to such lines from hydroelectric and pumped storage generating plants).

FIGURE 1

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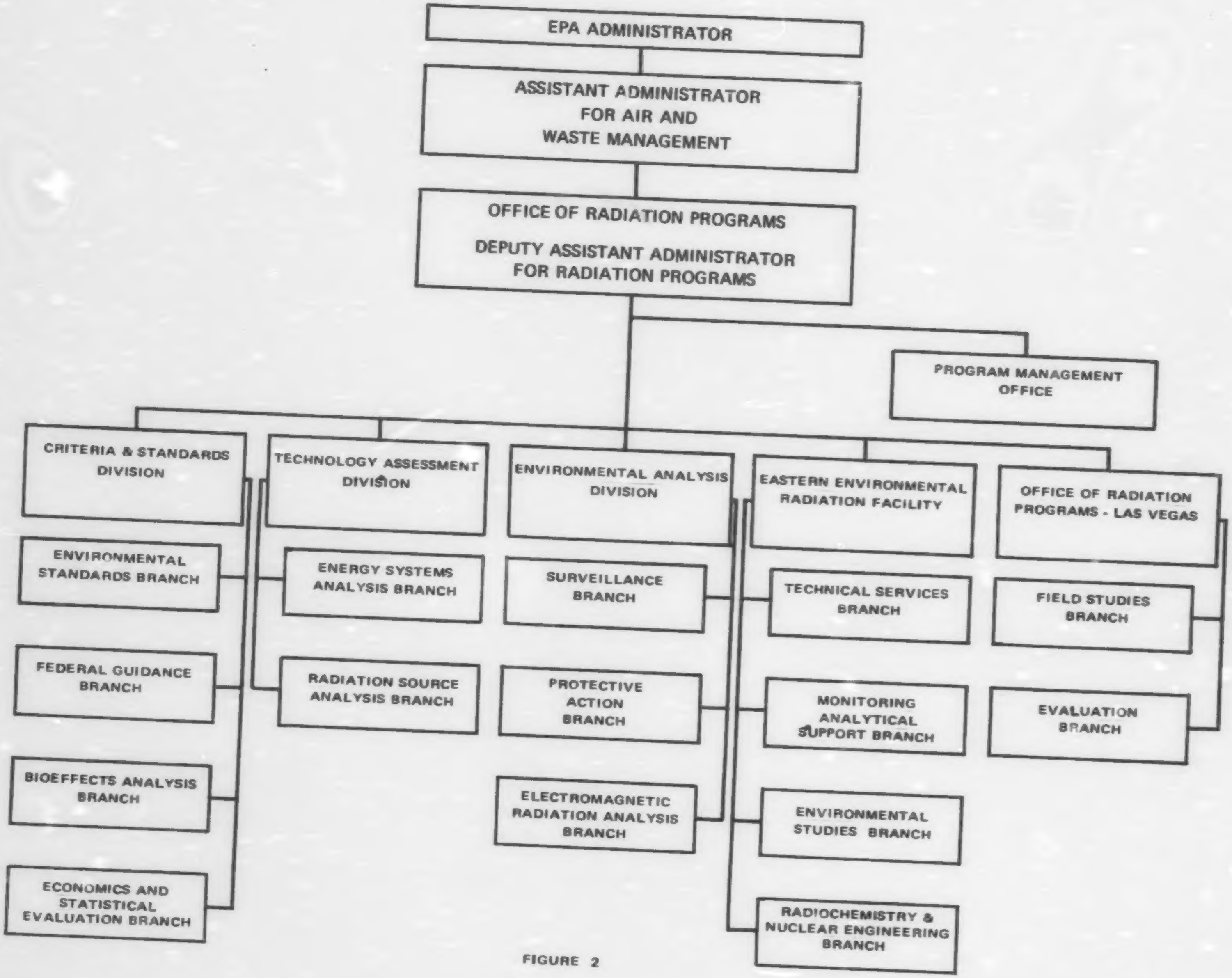
EPA ADMINISTRATOR
ASSISTANT ADMINISTRATOR FOR AIR AND WASTE MANAGEMENT
OFFICE OF RADIATION PROGRAMS
DEPUTY ASSISTANT ADMINISTRATOR FOR RADIATION PROGRAMS
PROGRAM MANAGEMENT OFFICE
CRITERIA & STANDARDS DIVISION
ENVIRONMENTAL STANDARDS BRANCH
FEDERAL GUIDANCE BRANCH
BIOEFFECTS ANALYSIS BRANCH
ECONOMICS AND STATISTICAL EVALUATION BRANCH
TECHNOLOGY ASSESSMENT DIVISION
ENERGY SYSTEMS ANALYSIS BRANCH
RADIATION SOURCE ANALYSIS BRANCH
ENVIRONMENTAL ANALYSIS DIVISION
SURVEILLANCE BRANCH
PROTECTIVE ACTION BRANCH
ELECTROMAGNETIC RADIATION ANALYSIS BRANCH
EASTERN ENVIRONMENTAL RADIATION FACILITY
TECHNICAL SERVICES BRANCH
MONITORING ANALYTICAL SUPPORT BRANCH
ENVIRONMENTAL STUDIES BRANCH
RADIOCHEMISTRY & NUCLEAR ENGINEERING BRANCH
OFFICE OF RADIATION PROGRAMS - LAS VEGAS
FIELD STUDIES BRANCH
EVALUATION BRANCH

FIGURE 2

D. 4

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

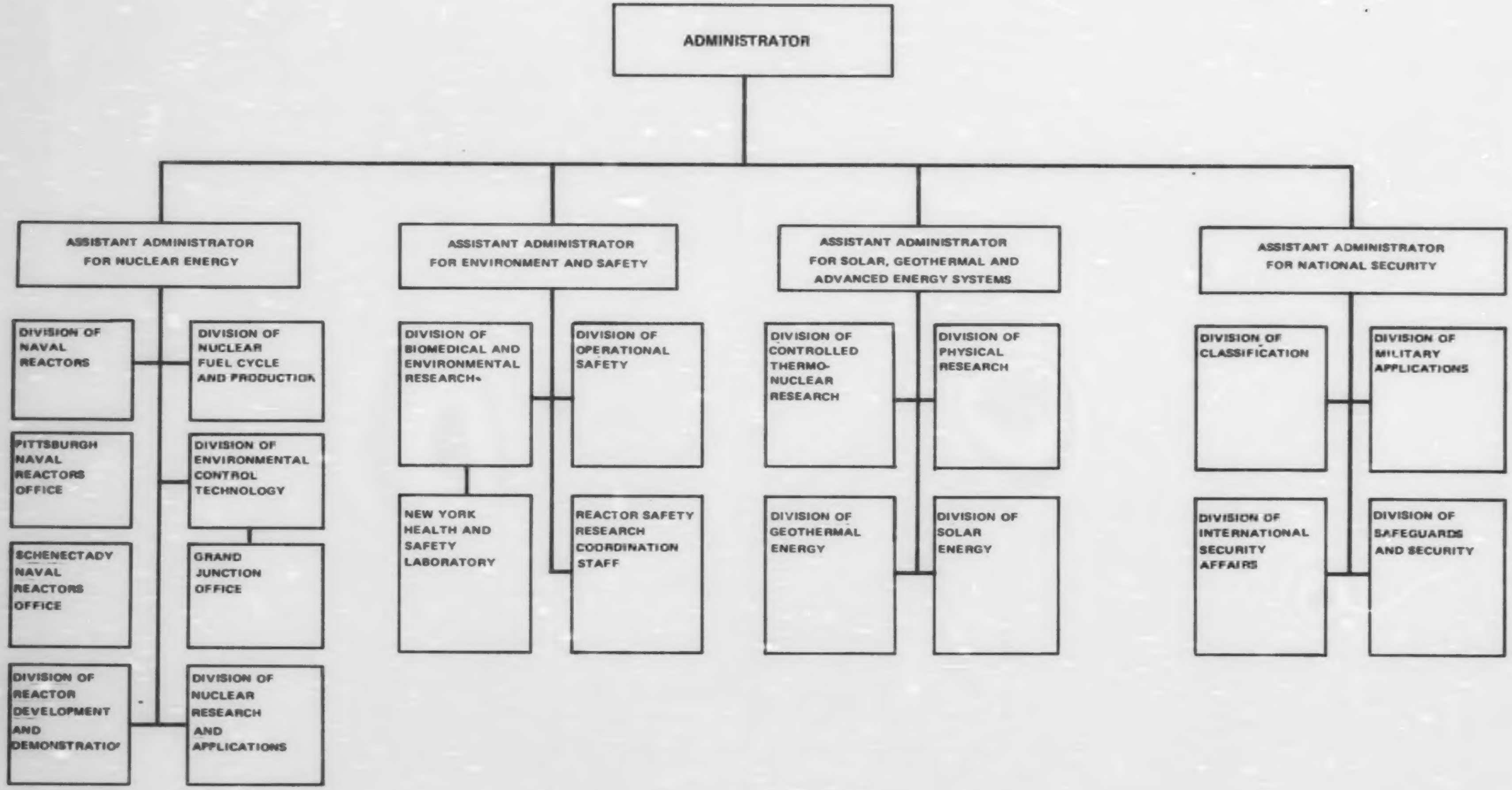
ADMINISTRATOR
ASSISTANT ADMINISTRATOR FOR NUCLEAR ENERGY
DIVISION OF NAVAL REACTORS
PITTSBURGH NAVAL REACTORS OFFICE
SCHENECTADY NAVAL REACTORS OFFICE
DIVISION OF REACTOR DEVELOPMENT AND DEMONSTRATIO
DIVISION OF NUCLEAR FUEL CYCLE AND PRODUCTION
DIVISION OF ENVIRONMENTAL CONTROL TECHNOLOGY
GRAND JUNCTION OFFICE
DIVISION OF NUCLEAR RESEARCH AND APPLICATIONS
ASSISTANT ADMINISTRATOR FOR ENVIRONMENT AND SAFETY
DIVISION OF BIOMEDICAL AND ENVIRONMENTAL RESEARCH*
NEW YORK HEALTH AND SAFETY LABORATORY
DIVISION OF OPERATIONAL SAFETY
REACTOR SAFETY RESEARCH COORDINATION STAFF
ASSISTANT ADMINISTRATOR FOR SOLAR, GEOTHERMAL AND ADVANCED ENERGY SYSTEMS
DIVISION OF CONTROLLED THERMO-NUCLEAR RESEARCH
DIVISION OF GEOTHERMAL ENERGY
DIVISION OF PHYSICAL RESEARCH
DIVISION OF SOLAR ENERGY
ASSISTANT ADMINISTRATOR FOR NATIONAL SECURITY
DIVISION OF CLASSIFICATION
DIVISION OF INTERNATIONAL SECURITY AFFAIRS
DIVISION OF MILITARY APPLICATIONS
DIVISION OF SAFEGUARDS AND SECURITY

FIGURE 3

DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

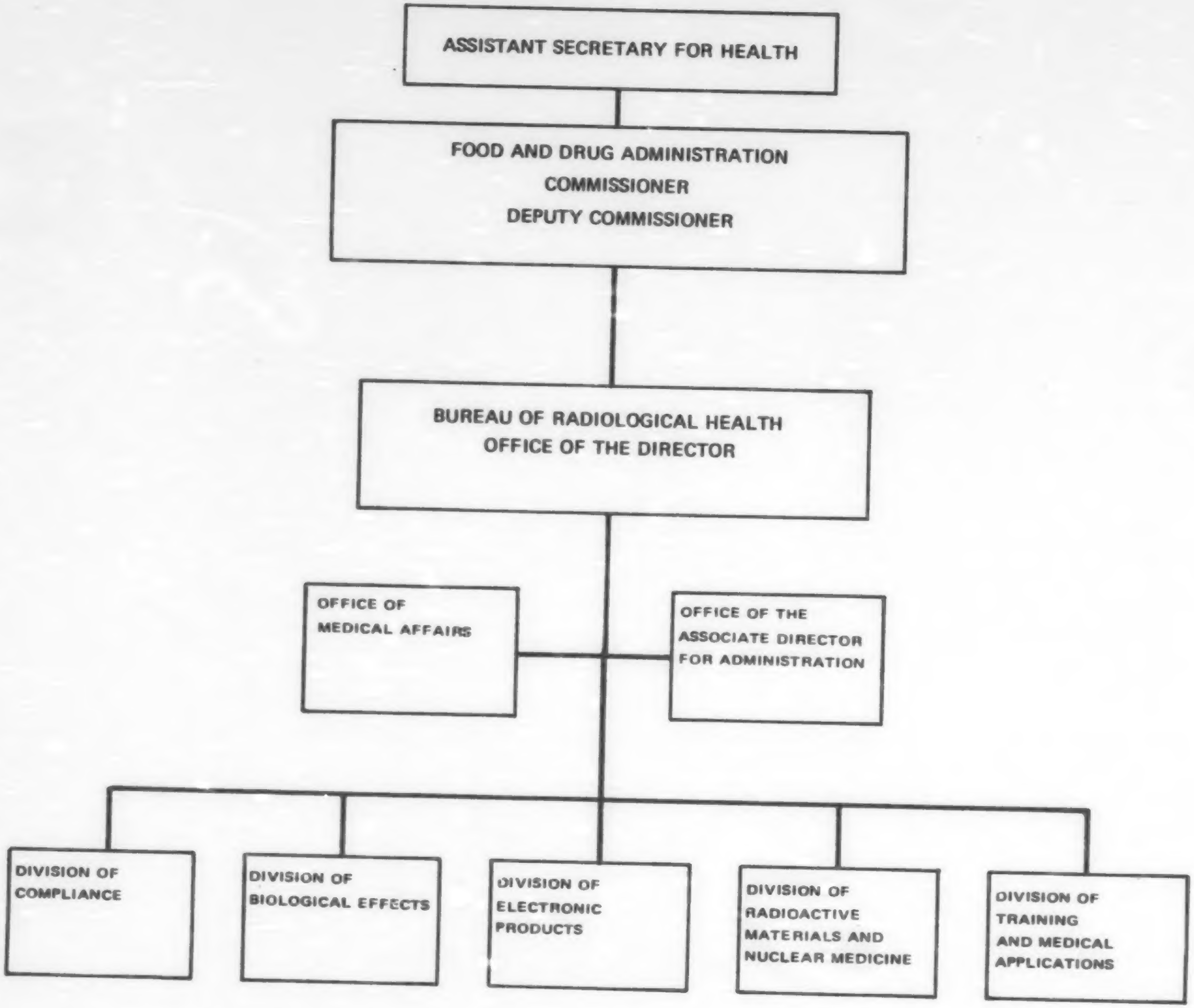
ASSISTANT SECRETARY FOR HEALTH
FOOD AND DRUG ADMINISTRATION COMMISSIONER DEPUTY COMMISSIONER
BUREAU OF RADIOLOGICAL HEALTH OFFICE OF THE DIRECTOR
OFFICE OF MEDICAL AFFAIRS
OFFICE OF THE ASSOCIATE DIRECTOR FOR ADMINISTRATION
DIVISION OF COMPLIANCE
DIVISION OF BIOLOGICAL EFFECTS
DIVISION OF ELECTRONIC PRODUCTS
DIVISION OF RADIOACTIVE MATERIALS AND NUCLEAR MEDICINE
DIVISION OF TRAINING AND MEDICAL APPLICATIONS

FIGURE 4

D.6

NUCLEAR REGULATORY COMMISSION

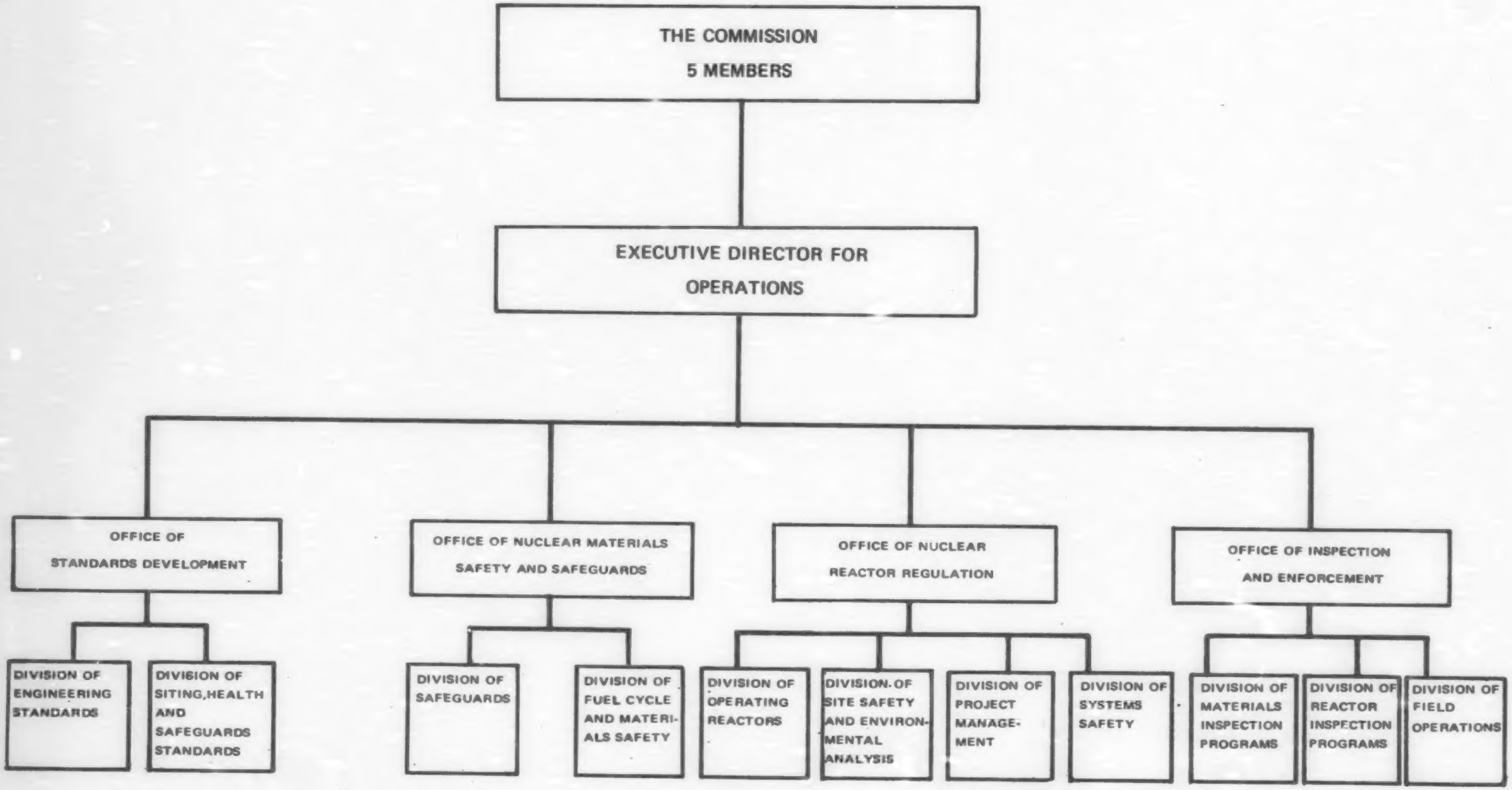
THE COMMISSION
5 MEMBERS
EXECUTIVE DIRECTOR FOR OPERATIONS
OFFICE OF STANDARDS DEVELOPMENT
OFFICE OF NUCLEAR MATERIALS SAFETY AND SAFEGUARDS
OFFICE OF NUCLEAR REACTOR REGULATION
OFFICE OF INSPECTION AND ENFORCEMENT
DIVISION OF ENGINEERING STANDARDS
DIVISION OF SITING, HEALTH AND SAFEGUARDS STANDARDS
DIVISION OF SAFEGUARDS
DIVISION OF FUEL CYCLE AND MATERIALS SAFETY
DIVISION OF OPERATING REACTORS
DIVISION OF SITE SAFETY AND ENVIRONMENTAL ANALYSIS
DIVISION OF PROJECT MANAGEMENT
DIVISION OF SYSTEMS SAFETY
DIVISION OF MATERIALS INSPECTION PROGRAMS
DIVISION OF REACTOR INSPECTION PROGRAMS
DIVISION OF FIELD OPERATIONS

FIGURE 5

APPENDIX E

ACRONYMS AND ABBREVIATIONS GLOSSARY

AEC	Atomic Energy Commission
ANSI	American National Standards Institute
BEIR	Biological Effects of Ionizing Radiation
BRH	Bureau of Radiological Health, Food and Drug Administration
CT	Computered Tomographic
DoD	Department of Defense
DoI	Department of Interior
DoT	Department of Transportation
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EPA/ORP	Environmental Protection Agency/Office of Radiation Programs
ERAMS	Environmental Radiological Ambient Monitoring System
ERDA	Energy Research and Development Administration
FDA	Food and Drug Administration
FNP	Floating Nuclear Plant
F.R.	Federal Register
FWPCA	Federal Water Pollution Control Act
GAO	General Accounting Office, U.S. Congress
GEIS	Generic Environmental Impact Statement
GHz	Gigahertz, a unit of frequency (1,000 MHz)
GSD	Genetically Significant Dose
HEW	Department of Health, Education, and Welfare

HTGR	High Temperature Gas Reactor
Hz	Hertz, basic unit of frequency
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiation Protection
LMFBR	Liquid Metal Fast Breeder Reactor
LOCA	Loss of Coolant Accident
LOFT	Loss of Fluid Test
LWR	Light Water Reactor
MESA	Mining Enforcement and Safety Administration, Department of Interior
MHz	Megahertz, a unit of frequency (1,000,000 hertz)
Microcuries	A unit of activity, abbreviated μCi (one-millionth of a curie)
Mrem	Millirem, a special unit of dose equivalent (1/1,000 rem)
mW	Milliwatt, a unit of power (1/1,000 watt)
NARM	Naturally-Occurring or Accelerator Produced Material
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NBS	National Bureau of Standards
NEPA	National Environmental Policy Act
NIOSH	National Institute of Occupational Safety and Health
NRC	Nuclear Regulatory Commission
NRDC	Natural Resources Defense Council
ORP	Office of Radiation Programs, Environmental Protection Agency
OSHA	Occupational Safety and Health Administration
OTP	Office of Telecommunications Policy
PAG	Protective Action Guide
pCi	Picocurie, a unit of activity (one millionth of a microcurie)

* U.S. GOVERNMENT PRINTING OFFICE : 1977 O-720-117/2027

ppm	Parts Per Thousand
Rad	A unit of absorbed dose
Rem	A special unit of dose equivalent
RF	Radiofrequency
TLD	Thermoluminescent Dosimeter
USGS	U.S. Geological Survey
WL(M)	Working Level (Month), a unit of concentration based on one liter of air (one WL is any combination of short-lived decay products of radon that will result in emission of a certain amount of alpha ray energy)